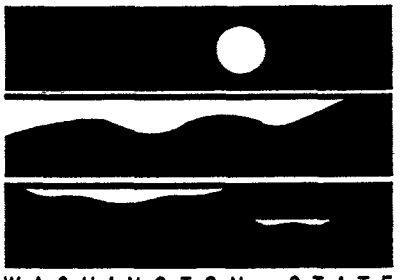

Department of Ecology 1993-94 Investigation of PCBs in the Spokane River

Toxics Investigations Section
Environmental Investigations and Laboratory Services Program
Olympia, Washington 98504-7710

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Abstract

The Washington State Department of Ecology conducted a series of investigations into the levels and sources of polychlorinated biphenyls (PCBs) in the Spokane River during July 1993 - September 1994. Data were obtained on PCBs in edible fish and crayfish tissue to support a human health evaluation by the Washington State Department of Health, currently in progress. The hazards posed to aquatic life and wildlife were assessed from data on PCB concentrations in samples of whole fish and river sediments. Industrial and municipal sources of PCBs to the river were identified, and recommendations made for follow-up sampling.

Summary

Introduction

During 1993 and 1994 the Washington State Department of Ecology (Ecology) conducted a series of investigations into PCB contamination of the Spokane River. PCBs (polychlorinated biphenyls) are a family of chemical compounds that were once used in a variety of applications including as insulating fluids, plasticizers, in inks and carbonless paper, and as heat transfer and hydraulic fluids. Because of their persistence and toxicity, the U.S. Environmental Protection Agency (EPA) restricted manufacture of PCBs to sealed systems in 1977 and banned all production in 1979.

The levels of PCBs in the environment have generally declined since the EPA ban. However, fish and sediment samples collected by Ecology from the lower Spokane River in 1990-92 showed unusually high concentrations of PCBs, leading to the surveys described in this report.

Objectives

The objectives of the 1993-94 sampling program were: 1) Provide data to identify better the human health implications from eating Spokane River fish, 2) Assess the potential hazard to aquatic life and wildlife, 3) Locate sources of PCBs and determine if they are historical or ongoing.

For the health risk assessment, 54 samples of edible fish and crayfish tissue were collected between the Washington-Idaho border and Spokane River mouth. The most frequently consumed species were selected for analysis, including yellow perch, largemouth bass, and rainbow trout, among other species. Each sample was a composite of tissue from up to eight individual organisms.

The data on PCBs in Spokane River fish were provided to the Washington State Department of Health (Health) for evaluation of potential human health implications. As of this writing, Health has not completed their evaluation of the data. **The human health issue is not addressed in the present report.**

The 1993-94 surveys also obtained some data on metals, particularly zinc, lead, and cadmium which are longstanding water quality concerns for the Spokane River. The source of this problem is in Idaho's Coeur d'Alene River drainage due to historical mining and related activities. Metals data are included in this report only as they relate to sediment toxicity.

PCB Terminology

PCB mixtures having a range of physical/chemical properties were formulated for commercial use and designated by a numbering system based on chlorine content. The PCBs detected in the Spokane River most closely resembled the commercial mixtures PCB-1248, PCB-1254, and PCB-1260. The last two digits are the average chlorine content by weight (e.g., PCB-1254 averages 54% chlorine) while the first two refer to the number of carbon atoms in biphenyl. In the United States, PCBs were produced under the trade name Aroclor (e.g., Aroclor-1254).

Once released to the environment, PCBs undergo alterations due to volatilization, uptake by biota, biodegradation, and mixing with PCBs from other sources. Because a single environmental sample may contain 100 - 150 individual PCB compounds, and because of overlap between compounds in different commercial mixtures, PCB analysis is complex.

PCB Concentrations in Spokane River Fish

PCB-1248, -1254, and -1260 were detected in most fish samples, but were rarely detectable in crayfish. Concentrations of total PCBs in fish ranged widely, from as low as 6 - 19 parts per billion (ppb) in fillets from Long Lake yellow perch to 2,780 ppb in whole largescale suckers in the upper river (see Figures 1 and 10). The maximum concentration of total PCBs found in crayfish was only 7 ppb. Whole fish samples generally had higher concentrations than fillets.

PCB concentrations in Spokane River fish gradually increase moving from the lower to upper river, with the highest levels occurring above Upriver Dam upstream of the city of Spokane. Concentrations return to low levels in Idaho. All samples collected above Nine-Mile Dam exceeded a median value of 84 ppb calculated from data on fish from other Washington rivers and lakes, and most also exceeded a U.S. urban/industrial median reported by EPA.

Among edible tissue samples, the highest total PCB concentrations were found in rainbow trout from above Upriver Dam (280 - 1,084 ppb) and in the Nine-Mile reservoir (205 - 589 ppb), and in mountain whitefish from the reach between the Upriver and Monroe St. dams (449 - 725 ppb). Most of the edible tissue samples from the lower river, Long Lake and the Spokane Arm of Lake Roosevelt, had PCB concentrations comparable to or not substantially above those typical of fish from other parts of Washington.

A number of the 1994 samples from the upper river, including rainbow trout, had much lower PCB concentrations than when the same species were analyzed in 1993. The 1994 data are based on a larger sample size and, therefore, may be more representative of PCB levels in the river. These lower results may also reflect actions taken to correct PCB problems at several industrial sites during 1992-93, as described below.

Ecological Implications

Many of the fish samples collected from the Spokane River during 1993-94 substantially exceeded levels of 100 - 110 ppb total PCBs that have been proposed by other states and agencies as being protective of fish-eating birds and mammals. Excluding a single extremely high result from 1993, the mean value for total PCBs in Spokane River whole fish was 675 ppb. This concentration is at a level that is likely to adversely affect aquatic organisms and their predators.

PCB concentrations in Spokane River sediments were below levels that have been found to cause significant toxicity to bottom-dwelling animals. Bioassays were conducted on sediments from three sites in the river. These tests did show evidence of toxicity above Upriver Dam and in the Spokane Arm, but this is probably due to high concentrations of zinc, lead, and cadmium.

Conclusions About PCB Sources

Results on fish and sediment samples indicated no significant sources of PCBs above Post Falls, Idaho. The largest PCB inputs to the Spokane River appear to have occurred between the state line and Upriver Dam. An area of very high PCB-1248 concentrations (2,400 - 4,500 ppb) was identified in the sediments approximately 1/4 mile above this dam.

In the reach between the state line and Monroe St. Dam there is a region of elevated PCB-1248 in the sediments beginning about 5 miles above Upriver Dam. Limited water sampling in this part of the river also detected PCB-1248, with concentrations increasing in a downstream direction. Four facilities within this reach were identified as having elevated concentrations of PCB-1248 in their waste streams, sludge or soil: Liberty Lake sewage treatment plant (STP), Spokane Industrial Park (SIP), Kaiser Trentwood, and an area adjacent to the old Inland Metals site (see Figure 9). These facilities are concluded to be current or historical sources of PCBs to the Spokane River.

No data are available to determine what the relative importance of each of these PCB sources has been or when discharge of PCBs may have begun. Current data on PCB discharges to the river exist only for Kaiser.

Liberty Lake STP had an unusually high level of PCB-1248 in its sludge. PCBs are infrequently detected in sludge at other Washington state municipal treatment plants.

Spokane Industrial Park discharged treated wastewater to the Spokane River until diverted to the Spokane sewage collection system in December 1993. Ecology samples collected in 1994 showed high concentrations of PCB-1248 in the SIP sludge. SIP conducted independent sampling in 1994 and reported the sludge as having a mixture of PCB-1248 and -1254; SIP also detected PCB-1254 in a sample of their wastewater discharge to the Spokane STP. The source of PCBs at SIP has not been identified.

The Kaiser Trentwood aluminum mill is currently discharging PCB-1248 to the river, although concentrations appear to have been reduced substantially following cleaning and relining of their treatment lagoon in 1992 - 93. Data collected by Ecology and by Kaiser indicate Kaiser's contribution of PCB-1248 to the river is on the same order as that found downstream, although uncertainties in determinations of PCB concentrations allow for the possibility of other sources also of the same magnitude. The PCB concentrations below Kaiser were trace level (estimated at 0.0015 parts per billion during low flow) and within EPA water quality criteria for protecting aquatic life.

Water quality criteria lower than the EPA aquatic life criteria have been set or proposed for PCBs, such as the EPA National Toxics Rule and Great Lakes Water Quality Initiative. It is beyond the scope of this report to recommend acceptable PCB concentrations for the Spokane River.

Kaiser has identified a cooling water line that has accumulated sediments high in PCBs and believes this is the source of -1248 in the final effluent. Kaiser plans to clean out and re-line the pipe by the fall of 1995.

The old Inland Metals site was a scrap metals salvaging operation that has probably been a source of PCB-1248 and -1260 to the river. Although contaminated soils were removed from this site by 1992, some residual contamination remains along the shoreline.

Samples from the three other facilities investigated -- Post Falls STP, a Washington Water Power Co. storage yard, and the Spokane STP -- had low to moderate levels of PCBs. Results on fish samples collected from the Little Spokane River, a tributary to upper Long Lake, indicated there may be a source of PCB-1260 within the Little Spokane drainage.

Recommendations

The following actions should be taken at the earliest opportunity or as indicated:

1. Re-sample sludge and do effluent sampling at the Liberty Lake sewage treatment plant (STP) to confirm and quantify its importance as a source of PCB-1248 to the river; trace the source of PCBs if warranted.

2. Collect additional samples at several points within the Spokane Industrial Park wastewater collection system to determine if there is a source of PCB-1248/ -1254 to the Spokane STP.

3. Re-analyze PCBs in effluent (#002) from the Kaiser Trentwood industrial wastewater treatment facility to confirm the presence of PCB-1260; identify sources as necessary.

4. Monitor Kaiser Trentwood's progress on PCB cleanup of their cooling water line; obtain data on the final effluent (#001) to determine if the effort was successful.

5. Review available information on potential sources of PCB-1260 to the Little Spokane River drainage, and sample as needed.

6. Re-sample fish in the upper Spokane River during August 1996 to determine if the level of PCB contamination has decreased from 1993-94 and extent to which PCBs remain a hazard to aquatic life and wildlife.

If human health or environmental concerns prompt further investigation, the following sites should be evaluated for possible importance as additional PCB sources to the river:

- Kaiser Trentwood stormwater and groundwater
- Sediments at Upriver Dam site #1
- Shoreline soil near old Inland Metals site
- Spokane STP

Acknowledgements

The Department of Ecology very much appreciates the helpful cooperation of the industrial and municipal facilities sampled as part of this investigation, particularly Sarah Hubbard-Gray with Pentzer Development Corporation representing SIP, and Pat Blau representing Kaiser.

Thanks are due local citizens R.E. Brown, Nadine Langford and Harry Jaremko for providing boat access to the river, and to Ray Good for providing a sample of crayfish from Long Lake.

Eric Johnson of Washington Water Power Co. gave valuable help in locating sampling sites and deploying sampling equipment.

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The high quality chemical analyses provided for this study by the Ecology/EPA Manchester Laboratory, especially Bob Reick, Dickey Huntamer, Norm Olson, Stuart Magoon, and Pam Covey, are gratefully acknowledged.

The field work for the Spokane PCB investigations was done by Dale Davis, Dave Serdar, Bill Yake, Dave Batts, Steve Golding, and Jim Cubbage of Ecology's Environmental and Laboratory Services Program (EILS), Lynn Singleton, Manager. EILS' Larry Goldstein coordinated the investigation.

Assistance in planning and carrying out the sampling program was provided by Ecology's Eastern Regional Office, particularly Carl Nuechterlein, Claude Sappington, Pat Hallinan, Ken Merrill, Don Nichols, and Keith Stoffel.

This report was compiled by Art Johnson, Steve Golding, Larry Goldstein, Dale Davis, Bill Yake, and Dave Batts of EILS. Figures 1 and 4 - 9 were prepared by Mike Woodall of EILS.

Word processing was done by Joan LeTourneau.

Introduction

Reason for PCB Study

Polychlorinated biphenyls (PCBs) were first detected in the Spokane River in fish samples collected by the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) during 1978-1983 (Bailey and Singleton, 1984; Joy, 1984; Hopkins et al., 1985). Because concentrations were not unusually high for U.S. freshwater fish at that time (Schmitt et al., 1983) and within existing guidelines for fisheries products (FDA, 1984) these findings did not result in further investigation.

In 1990, as part of an Ecology assessment of chemical contaminants in Lake Roosevelt, samples of fish and bottom sediments from the Spokane River Arm (Figure 1) were analyzed for PCBs (Johnson, 1991). Results indicated PCBs were persisting in the Spokane at levels well above those in other local rivers and lakes. Further sampling by Ecology in 1992 gave similar findings for Long Lake (Serdar et al., 1994).

The 1990-92 data prompted Ecology's Eastern Regional Office to request that the Environmental Investigations and Laboratory Services Program conduct an expanded survey of the river, analyzing sufficient numbers of samples to determine if and where PCB contamination was a significant concern. Findings from this effort completed in 1993, and an expanded series of PCB surveys that followed in 1994, are the subject of this report.

Metals Data

Metals, particularly zinc, lead, and cadmium, are a longstanding water quality concern for the Spokane River. The source of this problem is in Idaho's Coeur d'Alene River drainage due to historical mining and related activities (Mink et al., 1971; Yake, 1979; Patmont et al., 1987).

At the request of the Eastern Region, zinc, lead, cadmium, and a range of other metals were analyzed in conjunction with the 1993 PCB survey. Results are reported in Johnson et al. (1994a). Ecology has also evaluated the metals-related toxicity of Spokane River water and recommended total maximum daily loads for zinc, lead, and cadmium (Pelletier, 1994; Stinson et al., 1993). These reports describe the status of metals contamination in the river. Metals data are included in this report only as they relate to sediment toxicity.

Human Health Evaluation

The data obtained on PCBs in Spokane River fish during 1993 were provided to the Washington State Department of Health (Health) for review. They concluded the "PCB concentrations may be of health concern depending on an individual's rate of fish consumption", but that the number of samples analyzed was not sufficient "to adequately characterize PCB contamination levels of Spokane River fish" (Patrick, 1994). Patrick recommended that additional samples be collected in 1994, focusing on species and locations with the highest concentrations. He further recommended more data be obtained on lead, given the elevated concentrations found in several of the 1993 fish samples.

As of this writing, Health has not completed their review of the 1993-94 fish tissue data. **The human health issue is not addressed in this report, other than to provide and review data on the distribution of PCB residues in Spokane River fish.**

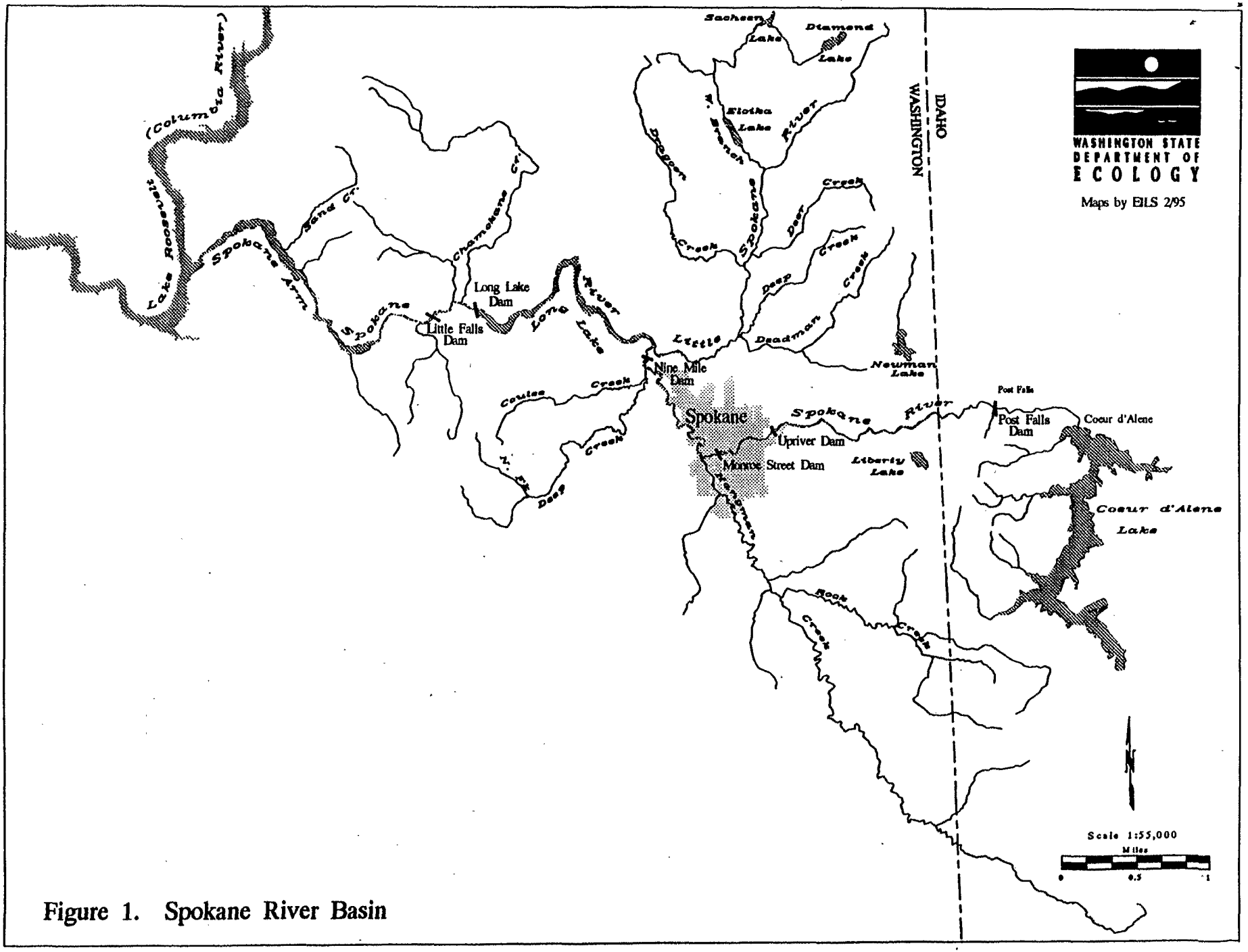

Figure 1. Spokane River Basin

Background on PCBs*

Chemical Structure and Use

PCBs are a family of chlorinated compounds with the general configuration shown in Figure 2. They share the basic structure of two six-membered carbon rings (biphenyl) and can have from 1 to 10 chlorine atoms. There are 209 PCB compounds possible depending on chlorine substitution patterns.

PCBs were first commercially produced in 1929. They were widely used in industrial applications as insulating fluids, plasticizers, in inks and carbonless paper, and as heat transfer and hydraulic fluids. After 1974 they were primarily used as insulating fluids in capacitors and transformers. EPA restricted manufacture of PCBs to sealed systems in 1977. In 1979 EPA banned PCB manufacture, processing, and distribution, but allowed continued use in closed electrical systems. EPA phased out use of electrical equipment containing PCBs through regulations in 1982 and 1985.

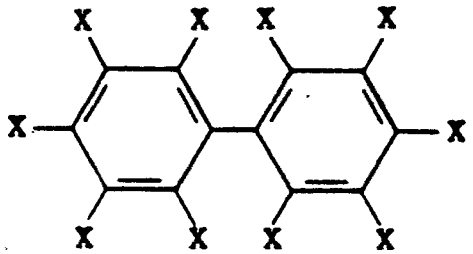

Figure 2. Structure of Polychlorinated Biphenyls (from Windholz et al., 1983)

* Information obtained from the following sources: Callahan et al. (1979); EPA (1991, 1993a&b); Hammond et al. (1972); Kalmaz and Kalmaz (1979); Peakall (1975); Tetra Tech (1992); and Schmitt et al. (1990).

PCB mixtures having a range of physical/chemical properties were formulated for commercial use and designated by a numbering system based on chlorine content. The mixtures most commonly reported in environmental samples are PCB-1242, PCB-1248, PCB-1254, and PCB-1260. The last two digits are the average chlorine content by weight (e.g., PCB-1254 averages 54% chlorine) while the first two refer to the number of carbon atoms in biphenyl. In the United States, PCBs were produced under the trade name Aroclor (e.g., Aroclor-1254). Approximately 150 of the 209 individual PCB compounds possible have been detected in the various Aroclor formulations.

Environmental Occurrence and Toxicity

Due to their persistence and widespread use, PCBs have been detected in all parts of the environment. While their solubility in water is low, they sorb strongly to organic matter and sediments. PCBs have high potential to bioaccumulate, particularly in the fat (lipid) of fish and other organisms. Concentration factors from water to fish are reported in the range of 26,000 to 660,000 fold. PCBs have been the subject of numerous environmental monitoring programs. Currently there are 31 states with fish consumption advisories for PCBs, more than for any other chemical contaminant.

A number of studies have documented a significant decrease in PCB levels in fish and other media since the EPA ban. Between 1976 and 1984, mean PCB concentrations decreased in U.S. freshwater fish by approximately 60%. The rate of decrease appears to have slowed in the U.S. since the mid-1980s, as PCBs approach trace levels in many waterbodies.

While the effects of PCBs on humans are controversial, they have been shown to adversely affect a number of organs and systems in animals including the reproductive system, immune system, central nervous system, thyroid and adrenal glands, and liver. Some PCBs have been shown to cause cancer in laboratory animals. In general, the more highly chlorinated PCB mixtures are the most toxic. Sensitivity to PCBs varies substantially between species. PCBs have been implicated in declines of fish and wildlife populations such as Great Lakes lake trout and Columbia River mink.

The effects of commercial PCB mixtures have been extensively tested on laboratory animals. Because of the large number of compounds involved and changes the mixtures undergo in the environment, there is not a precise link between effects observed with experimental doses of commercial mixtures and those due to residues measured in the environment.

Analytical Considerations

PCB analysis is complex. This point is illustrated by Figure 3 showing the multiple and overlapping peaks obtained when analyzing commercial Aroclors. Numbers above each peak designate the number of chlorine atoms in the compounds.

Once released to the environment, PCBs undergo alterations due to volatilization, uptake by biota, biodegradation, and mixing with PCBs from other sources. A single environmental sample may contain 100 - 150 individual PCB compounds. As a result, the distribution of PCBs in environmental samples may not always be adequately described in terms of one or more commercial mixtures.

PCBs can be analyzed and reported as equivalent concentrations of commercial Aroclor mixtures (this study) or as individual compounds. The only quantitative health risk estimates currently available are for Aroclors. Therefore, for purposes of assessing public health concerns, EPA currently recommends that PCBs be analyzed as Aroclor equivalents (e.g., PCB-1254) with total PCB concentrations reported as the sum of Aroclors (EPA, 1993b). Aroclor information can also be useful for tracking potential sources.

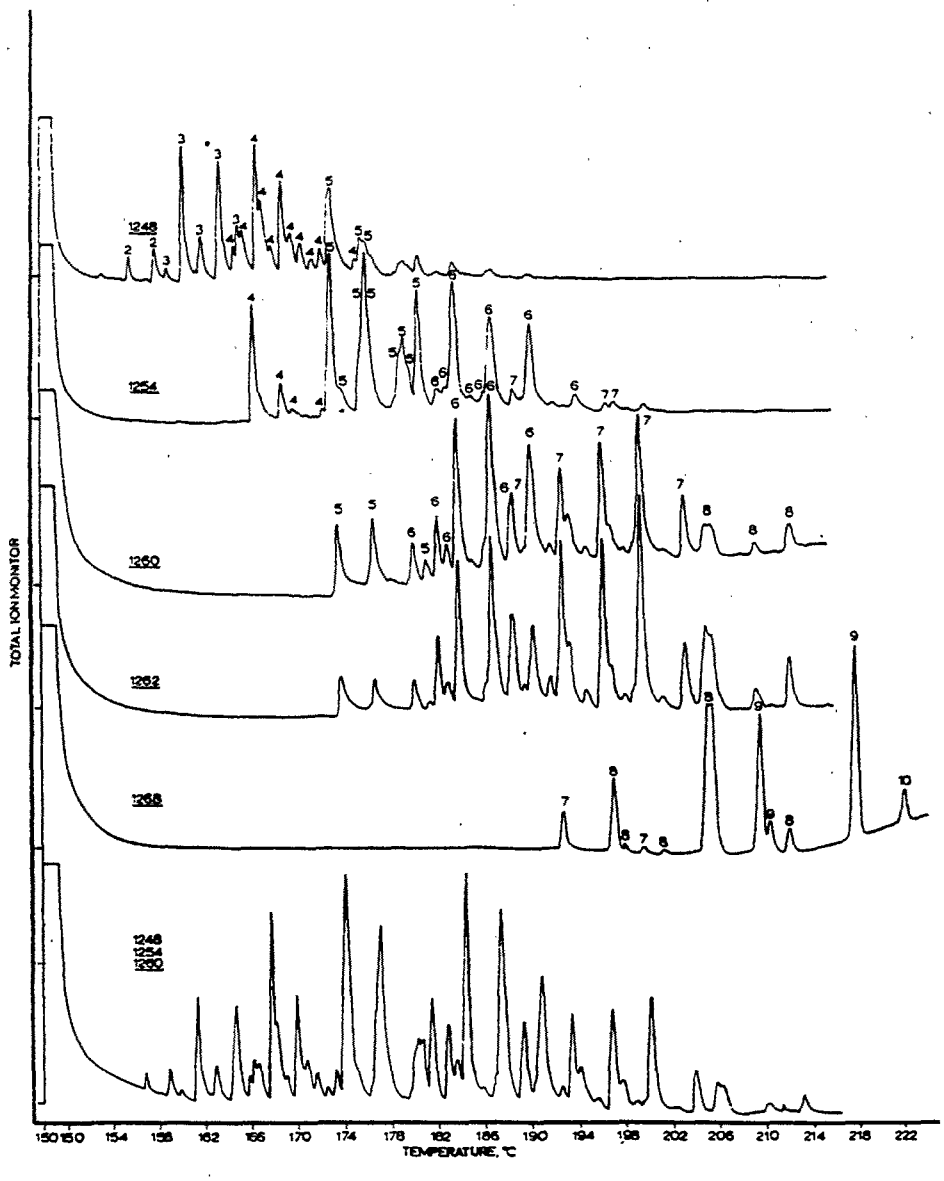

Figure 3. Chromatograms of Aroclor (PCB) mixtures (from Stalling & Huckins, 1971)

Spokane River PCB Sampling During 1993-94

Objectives and Overview of Ecology's Surveys

Between July 1993 and September 1994 Ecology conducted seven surveys related to PCB contamination of the Spokane River. Table 1 summarizes the locations, types, and number of samples collected. The reports cited in Table 1 and the methods descriptions in Appendix A provide detailed information on how this work was done.

Table 1. Dept. of Ecology Spokane River Sampling During 1993 & 1994

Date	Locations	Sample Type	No. of Samples	Analysis	Reference
7-8/93	Post Falls to Spokane Arm	Fish, Crayfish, and Sediments	17 5	PCBs/metals " "	Johnson et al. (1994a) & Huntamer (1994b)
5/94	Spokane Industrial Park	Sludge	1	PCBs	Davis & Yake (1994)
	Kaiser Trentwood	Sludge/Sediment	3	"	
	Wash. Water Power Yard	Soil	1	"	
	Inland Metals (former site)	Soil	1	"	
	Beaches	Sediment	2	"	
8/94	Kaiser Trentwood	Effluent	2	PCBs	Golding (1994)
	Spokane Industrial Park	Effluent	2	"	
	" " "	Sludge	1	"	
	Spokane STP	Sludge	1	"	
	Liberty Lake STP	Sludge	1	"	
	Post Falls STP	Sludge	1	"	
8-9/94	State Line to Plante's Ferry Park	River Particulates SPMDs	2 3	PCBs "	Golding (1994) Johnson & Golding (1994)
8/94	Post Falls to Division St.	Sediment	14	PCBs	Johnson et al. (1994b)
8/94	Upriver Dam, Long Lake & Spokane Arm	Sediment	3	Bioassay/PCBs/ BNAs/metals	Batts & Johnson (1994)
8/94	Post Falls to Spokane Arm	Fish and Crayfish	49	PCBs/lead	Johnson (1994)

SPMDs = semipermeable membrane device
BNA's = base/neutral/acid compounds

The surveys had three objectives:

1) Provide data to identify better the human health implications from eating Spokane River fish

Surveys conducted in July-August 1993 and August 1994 provided data on PCBs in 54 composite samples of edible fish and crayfish tissues collected between the Washington-Idaho border and the Spokane River Arm of Lake Roosevelt (Figure 4). Lead was also analyzed in a subset of the edible tissue samples. Ancillary data obtained on fish samples included total length, fresh weight, and percent lipid. Length and weight data are in Appendix B and C.

The most frequently consumed fish species were selected for analysis, based on information obtained through the Washington Department of Fish and Wildlife (Hisata, 1994a&b) and Washington Water Power Co. (Johnson et al., 1992). These included yellow perch, largemouth bass, and rainbow trout, among other species.

Each tissue sample consisted of a composite of skin-on fillets (scales removed) from up to 8 individual specimens. Abdominal (tail) muscle was analyzed for crayfish. A total of 289 individual sport fish and 56 crayfish were analyzed in the composite samples.

Sample sizes for the fish tissue survey were selected to meet data requirements of the state Department of Health. Chemical analysis of the 1994 samples was completed October 26, 1994. The data were provided to Health on November 30, 1994 (Johnson, 1994).

2) Assess the potential hazard to aquatic life and wildlife

PCB data pertinent to this assessment were obtained for 24 sediment and 10 whole fish samples collected from the Lake Coeur d'Alene outlet to the Spokane Arm during four surveys in 1993-94. Bioassays for sediment toxicity and expanded chemical analyses were also conducted on one sediment sample each from behind Upriver Dam, in Long Lake, and in the Spokane Arm during August 1994. Sites for bioassay were selected to encompass the range of PCB and metals concentrations found in 1993. Figures 5 - 8 show where the sediments were collected. Appendix D has detailed information on sampling locations.

Whole fish samples were of largescale suckers, a bottom-living species. Suckers were also analyzed as composites, typically of five or more specimens. Forty-nine individual suckers were used in the composites.

Sediment samples consisted of the top 2-cm (approximately 1 inch) surface layer of sediment, or for bioassays, the top 5-cm layer. Five or more grabs were composited for each sample. Sediment samples were also analyzed for total organic carbon (TOC), grain size, and percent solids. Sampling sites upstream of Nine-Mile Dam were selected for the presence of fine-grained material, which would be expected to be depositional areas for PCBs.

3) Locate sources of PCBs and determine if they are historical or ongoing

Based on results of the 1993 survey, efforts to identify PCB sources focused on the upper river (Figure 9). During May and August 1994, samples of sludge, treatment lagoon sediments, soil, and effluent were collected from the four industrial facilities and three sewage treatment plants (STPs) listed in Table 1. These sites were recommended for sampling by the Ecology Eastern Regional Office.

Particulate and soluble phase PCB concentrations were also measured in the river above and below Liberty Lake STP, Spokane Industrial Park, and Kaiser Trentwood. The low water solubility of PCBs called for sampling techniques that would concentrate PCBs from river water. PCBs associated with suspended particulate matter were collected by concentrating this material using flow-through centrifuges. Dissolved PCBs were extracted from river water with a semipermeable membrane sampling device (SPMD). These samples were collected during a period of low flow in July-September, 1994.

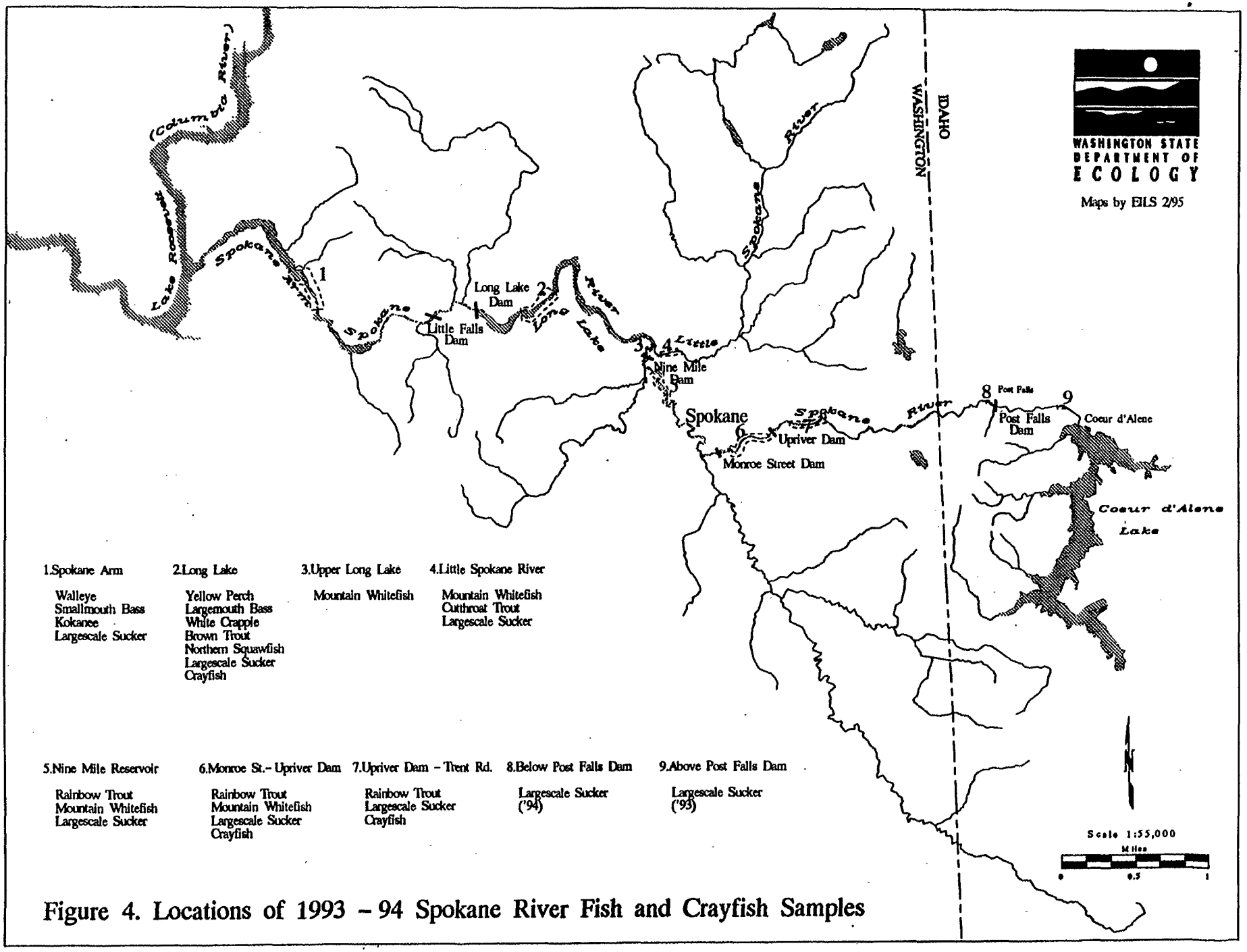

Figure 4. Locations of 1993 – 94 Spokane River Fish and Crayfish Samples

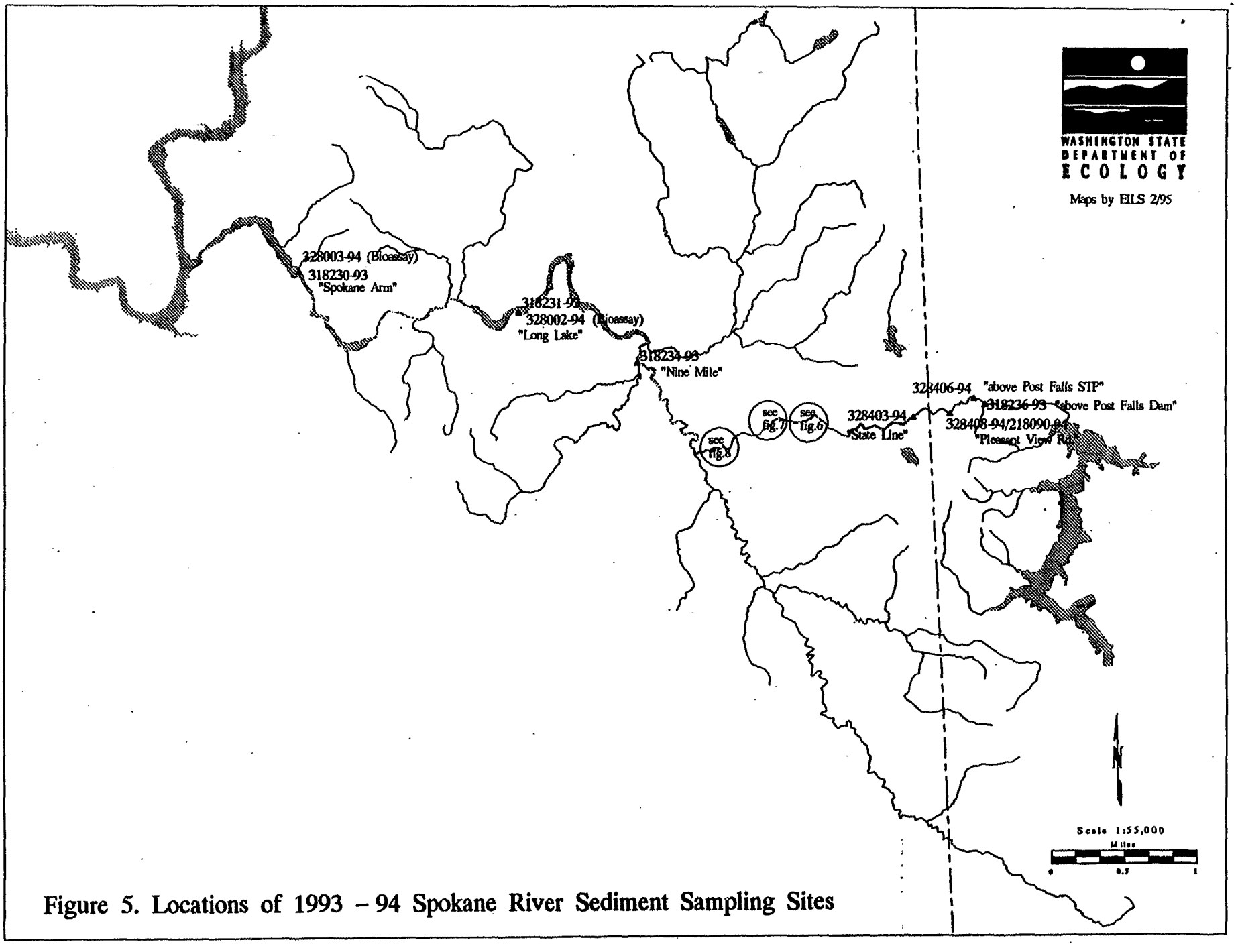

Figure 5. Locations of 1993 – 94 Spokane River Sediment Sampling Sites

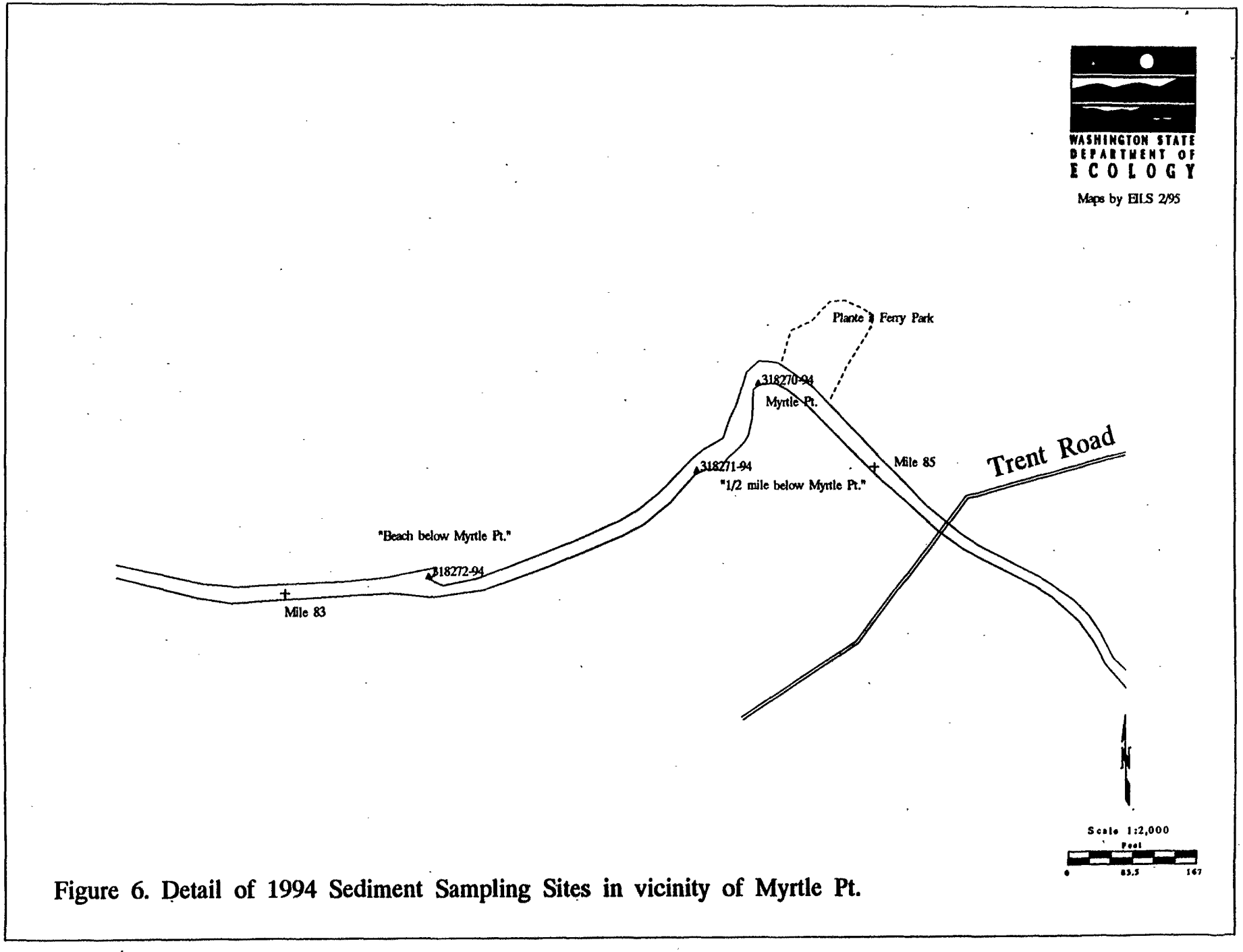

Figure 6. Detail of 1994 Sediment Sampling Sites in vicinity of Myrtle Pt.

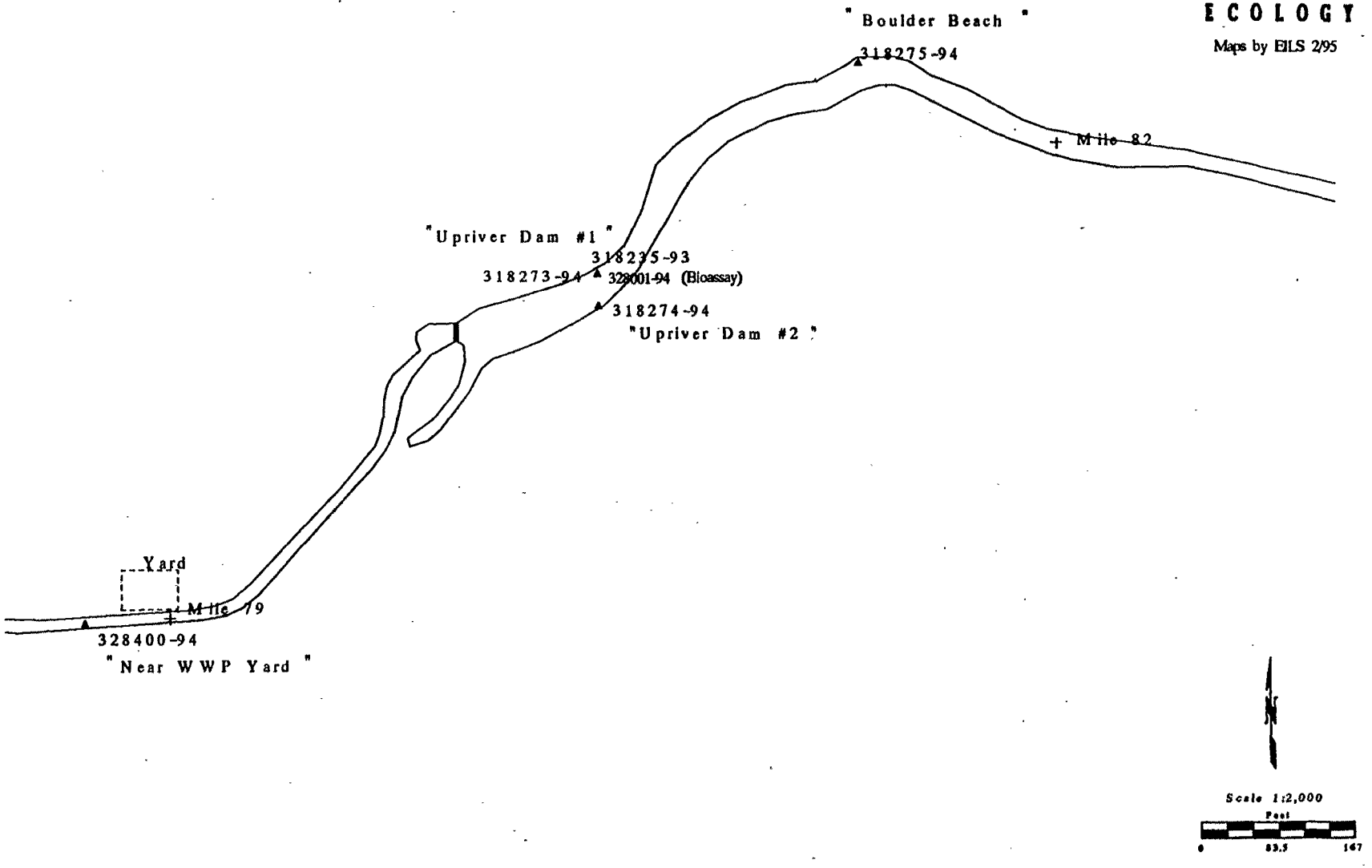

Figure 7. Detail of 1993-94 Sediment Sampling Sites in vicinity of Upriver Dam

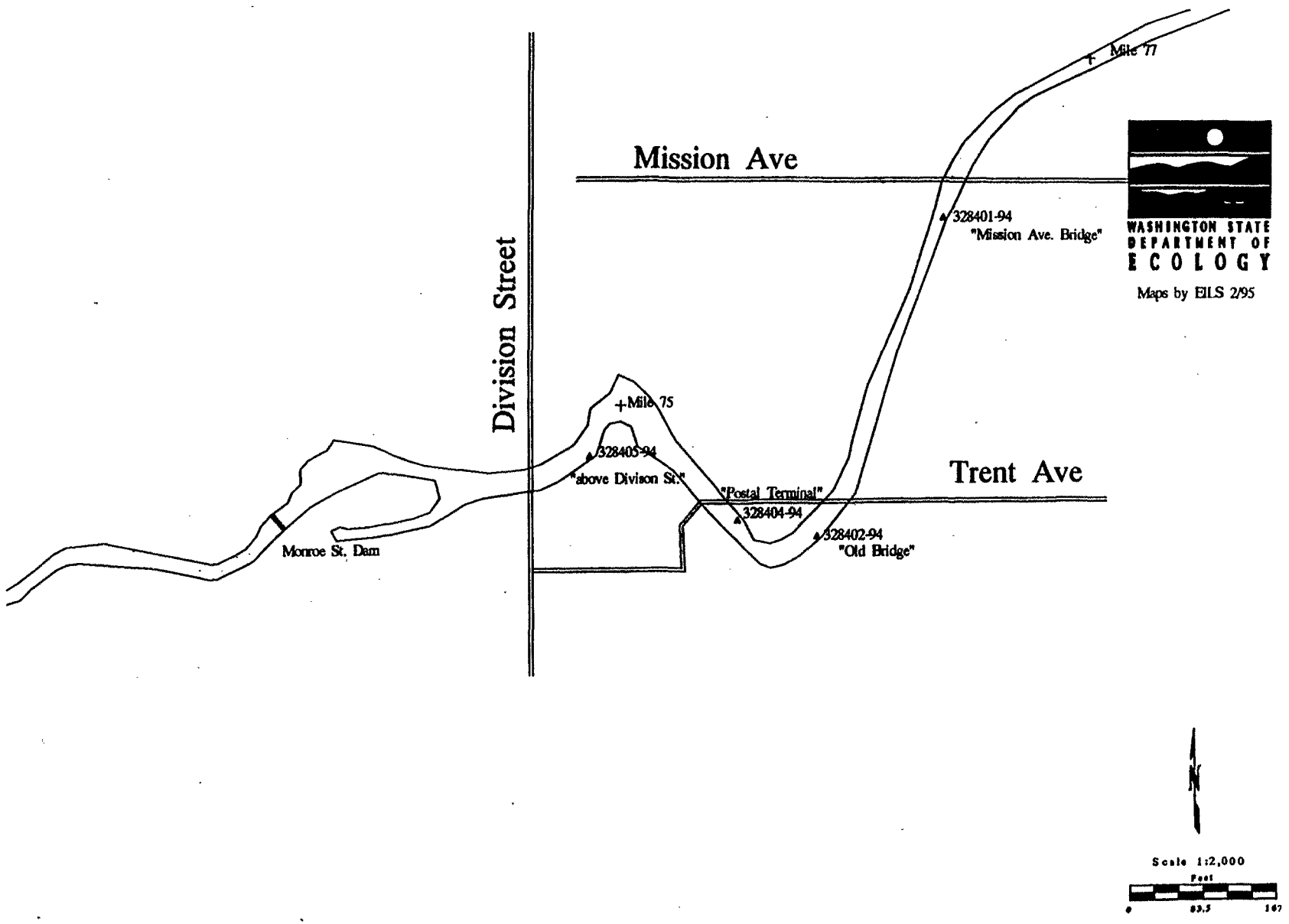

Figure 8. Detail of 1994 Sediment Sampling Sites between Mission Ave. and Division St.

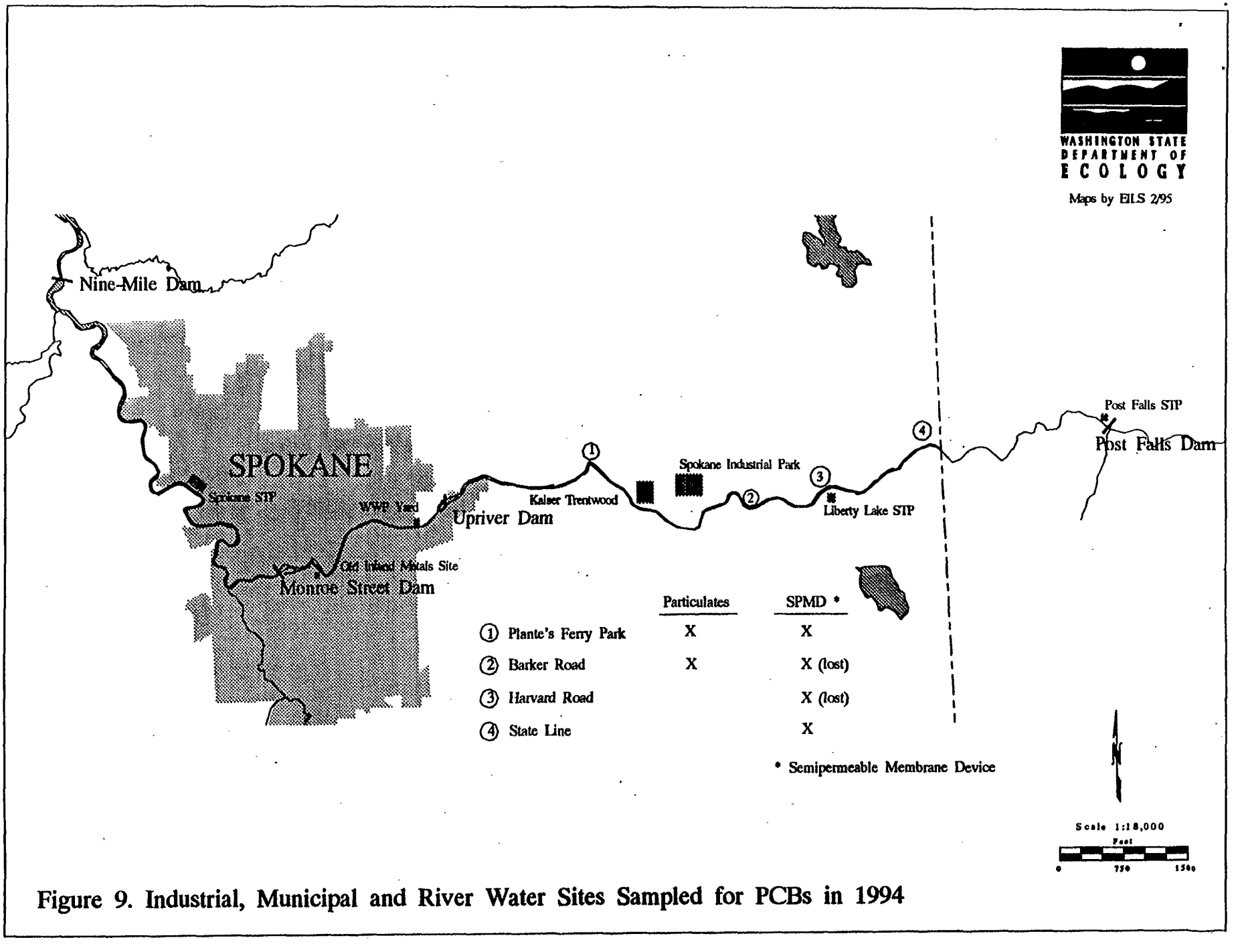

Figure 9. Industrial, Municipal and River Water Sites Sampled for PCBs in 1994

Results and Discussion*

PCB Concentrations in 1993-94 Fish Samples

The data obtained on PCBs in Spokane River fish during 1993-94 are in Table 2 (edible tissue) and Table 3 (whole fish). In these tables and those that follow, PCB detections are shown in bold print to differentiate from results where PCBs were not detected.

PCB compounds detected in fish tissue most closely resembled the commercial mixtures PCB-1248, -1254 and -1260. The results for PCB-1248 and -1254 are qualified as estimated concentrations because of the overlap of compounds common to both mixtures.

PCB-1254 was the primary mixture identified in the fish tissues, typically accounting for approximately 50% of total PCBs. PCB-1248 generally occurred in higher concentrations relative to -1254 and -1260 in upper river fish, while -1260 was relatively more important in fish from the lower river.

PCBs were detected in all fish samples, but were rarely detectable in crayfish. Concentrations of total PCBs in fish ranged widely, from as low as 6 - 19 ppb in fillets from Long Lake yellow perch to 2,780 ppb in whole largescale suckers above Upriver Dam. The maximum concentration of total PCBs found in crayfish was only 7 ppb. Whole fish samples generally had higher concentrations than fillets.

Figure 10 illustrates how levels of PCBs in edible and whole fish samples varied between different parts of the river during 1993-94. For comparison, the figure includes Washington state and national medians for PCBs in freshwater fish. Data for the Little Spokane River and results on crayfish were not plotted.

The state median for total PCBs (84 ppb) is from 1992-93 data obtained through Ecology's Washington State Pesticide Monitoring Program (Davis and Johnson, 1994; unpublished 1993 data). This value is from edible and whole fish samples collected at 13 rivers and lakes state-wide; primarily in areas of urban, rural, and agricultural land-use, but not including industrial sites.

*In this report, PCB concentrations are expressed in units of ug/Kg or ug/L (micrograms of PCBs per kilogram or liter of sample). Concentrations of 1 ug/Kg and 1 ug/L are equivalent to 1 part per billion (ppb). Fish tissue concentrations are on a wet (fresh) weight basis; sediment and other solids concentrations are on a dry weight basis. The term "total PCBs" means the sum of concentrations detected as PCB-1248, -1254, and -1260, with a value of zero used for non-detects.

Table 2. PCBs in Edible Tissues of Spokane River Fish Collected in 1993 & 1994 (ug/Kg (ppb) wet wt.)

Sample Number	Species	N =	Percent Lipid	PCB-1248	PCB-1254	PCB-1260	Total PCBs
			Trent Rd. to Upriver Dam				
94-318264	Crayfish	8	0.1	8 U	8 U	8 U	nd
94-318265	"	8	0.2	7 U	7 U	7 U	nd
94-318266	"	8	0.1	6 U	6 U	**7**	**7**
93-318256	Rainbow Trout	5	1.7	**400 J**	**550 J**	78 U	**950 J**
93-318255	" "	5	1.9	**400 J**	**610 J**	**74**	**1084 J**
94-318260	Rainbow Trout	8	2.9	**133 J**	**197 J**	**63**	**393 J**
"	(duplicate analysis)		na	**127 J**	**193 J**	**57**	**377 J**
94-318261	Rainbow Trout	8	2.5	**240 J**	**390 J**	**110**	**740 J**
94-328437	(duplicate analysis)		2.8	**172 J**	**218 J**	**81**	**471 J**
94-318262	Rainbow Trout	8	3.7	**130 J**	**110 J**	**40**	**280 J**
			Upriver Dam to Monroe St. Dam				
94-328432	Crayfish	8	0.2	7 U	7 U	7 U	nd
94-328433	"	8	0.3	7 U	7 U	7 U	nd
94-328434	"	8	0.2	7 U	7 U	7 U	nd
94-328425	Rainbow Trout	8	1.2	**29 J**	**67 J**	**68**	**164 J**
94-328426	" "	7	1.1	**27 J**	**44 J**	**40**	**111 J**
94-328427	" "	7	1.2	**39 J**	**71 J**	**51**	**161 J**
94-328428	Mountain Whitefish	8	5.6	**139 J**	**261 J**	**130**	**530 J**
94-328429	" "	8	5.5	**99 J**	**311 J**	**39**	**449 J**
94-328430	" "	8	4.6	**174 J**	**462 J**	**89**	**725 J**
			Nine-Mile Reservoir				
93-318254	Mountain Whitefish	5	2.7	**200 J**	**280 J**	**42**	**522 J**
94-318257	" "	8	6.9	**56 J**	**30 J**	**34**	**120 J**
94-318258	" "	8	8.4	**43 J**	**35 J**	**33**	**111 J**
94-318259	" "	8	6.6	**91 J**	**20 J**	**74**	**185 J**
93-318253	Rainbow Trout	4	2.7	**200 J**	**210 J**	**64**	**474 J**
93-318252	" "	4	2.9	**200 J**	**240 J**	**65**	**505 J**
94-318254	" "	6	5.4	**52 J**	**98 J**	**170**	**320 J**
94-318255	" "	6	3.0	**44 J**	**76 J**	**85**	**205 J**
94-318256	" "	6	5.2	**59 J**	**410 J**	**120**	**589 J**

N = number of fish in composite sample
U = not detected at or above reported value (i.e., less than)
J = estimated value
na = not analyzed
nd = not detected
Note: detected concentrations in bold print

Table 2. (continued)

Sample Number	Species	N =	Percent Lipid	PCB-1248	PCB-1254	PCB-1260	Total PCBs
			Little Spokane River				
94-318242	Cutthroat Trout	1	3.5	**23 J**	**55 J**	**110**	**188 J**
94-318237	Mountain Whitefish	8	2.5	**20 J**	**35 J**	**90**	**145 J**
94-318238	" "	8	2.2	**20 J**	**45 J**	**170**	**235 J**
94-318239	" "	8	3.2	**25 J**	**50 J**	**210**	**285 J**
			Long Lake				
93-318248	Crayfish	5	0.4	17 U	17 U	17 U	nd
94-318253	"	3	na	9 U	9 U	9 U	nd
93-318251	Yellow Perch	5	0.2	10 U	**9.2 J**	7.1 U	**9.2 J**
"	(duplicate analysis)	5	na	10 U	**9.6 J**	6.8 U	**9.6 J**
94-318244	Yellow Perch	8	0.2	6 U	**9 J**	6 U	**9 J**
94-318245	" "	8	0.2	6 U	**10 J**	**6 J**	**16 J**
94-318246	" "	8	0.2	6 U	**6 J**	6 U	**6 J**
93-318249	Largemouth Bass	5	0.6	45 U	**74 J**	**23**	**97 J**
94-318240	" "	5	1.0	**20 J**	**38 J**	**36**	**94 J**
94-318247	" "	5	1.1	**27 J**	**53 J**	**24**	**104 J**
94-318243	White Crappie	7	2.5	**22 J**	**46 J**	**29**	**97 J**
94-328436	(duplicate analysis)		2.5	**24 J**	**42 J**	**32 J**	**98 J**
94-318241	Brown Trout	3	4.0	**40 J**	**90 J**	**63**	**193 J**
93-318250	Mountain Whitefish	5	3.5	**200 J**	**410 J**	**170**	**780 J**
94-318249	" "	8	3.6	**38 J**	**52 J**	**60**	**150 J**
94-318250	" "	7	3.4	**23 J**	**38 J**	**57**	**118 J**
94-318251	" "	7	1.9	**18 J**	**19 J**	**34**	**71 J**
94-318233	Northern Squawfish	8	1.5	**40 J**	**150 J**	**110**	**300 J**
94-318234	"	8	1.6	**30 J**	**100 J**	**76**	**206 J**
94-318235	"	8	1.2	**30 J**	**100 J**	**70**	**200 J**
			Spokane Arm				
93-318247	Smallmouth Bass	5	1.2	20 U	**28 J**	7.1 U	**28 J**
93-318245	Walleye	5	0.4	8.8 U	**15 J**	8.8 U	**15 J**
94-318230	"	8	0.9	7 U	**20**	**11**	**31**
94-318231	"	8	0.8	**15 J**	**30 J**	**13**	**58 J**
94-318232	"	8	0.9	**14 J**	**25 J**	**11**	**50 J**
93-318246	Kokanee	2	4.4	50 U	**70 J**	**22**	**92 J**

Table 3. PCBs in Spokane River Whole Fish Samples Collected in 1993 & 1994 (ug/Kg (ppb) wet wt.)

Sample Number	Species	N =	Percent Lipid	PCB-1248	PCB-1254	PCB-1260	Total PCBs
			Post Falls, Idaho				
93-318244	Largescale Sucker	1	7.2	28 U	**55**	**41**	**96**
94-328435	" "	5	5.5	39 U	**81**	**71**	**152**
			Trent Rd. to Upriver Dam				
93-318243	Largescale Sucker	5	4.3	**800 J**	**1800 J**	**180**	**2780 J**
"	(duplicate analysis)		na	**800 J**	**1800 J**	**170**	**2770 J**
94-318263	Largescale Sucker	5	3.6	**230 J**	**230 J**	**71**	**531 J**
			Upriver Dam to Monroe St. Dam				
94-328431	Largescale Sucker	5	1.2	**34 J**	**96 J**	**71**	**201 J**
			Nine-Mile Reservoir				
93-318242	Largescale Sucker	5	5.6	**400 J**	**600 J**	**210**	**1210 J**
			Little Spokane River				
94-318236	Largescale Sucker	5	4.3	**40 J**	**140 J**	**260**	**440 J**
			Long Lake				
93-318241	Largescale Sucker	5	2.3	**100 J**	**180 J**	**130**	**410 J**
94-318248	" "	8	3.4	**140 J**	**410 J**	**270**	**820 J**
			Spokane Arm				
93-318240	Largescale Sucker	5	5.1	**200 J**	**250 J**	**190**	**640 J**

N = number of fish in composite sample
U = not detected at or above reported value (i.e., less than)
J = estimated value
na = not analyzed

The U.S. urban/industrial median (213 ppb) is based on fish collected primarily during 1987 as part of an EPA national study of bioaccumulative pollutants (Tetra Tech, 1992). Sampling sites for this work were near known or potential contaminant sources. The EPA median was also calculated from pooled data on edible tissue and whole fish.

Figure 10 shows that PCB concentrations in Spokane River fish gradually increase moving from the lower to upper river, with the highest levels occurring above Upriver Dam. Concentrations return to low levels (96 - 152 ppb) in Idaho. All samples collected above Nine-Mile Dam exceeded the state median, and most of these also exceeded the U.S. urban/industrial median.

Among edible tissue samples, the highest total PCB concentrations were found in rainbow trout from above Upriver Dam (280 - 1,084 ppb) and in the Nine-Mile reservoir (205 - 589 ppb), and in mountain whitefish from the reach between the Upriver and Monroe St. dams (449 - 725 ppb). These concentrations are 2 1/2 - 13 times higher than the Washington state median.

Most of the edible tissue samples from Long Lake (except squawfish) and the Spokane Arm had PCB concentrations comparable to or not substantially above those typical of fish from other parts of Washington. However, whole fish samples from Long Lake and the Spokane Arm were elevated (410 - 820 ppb).

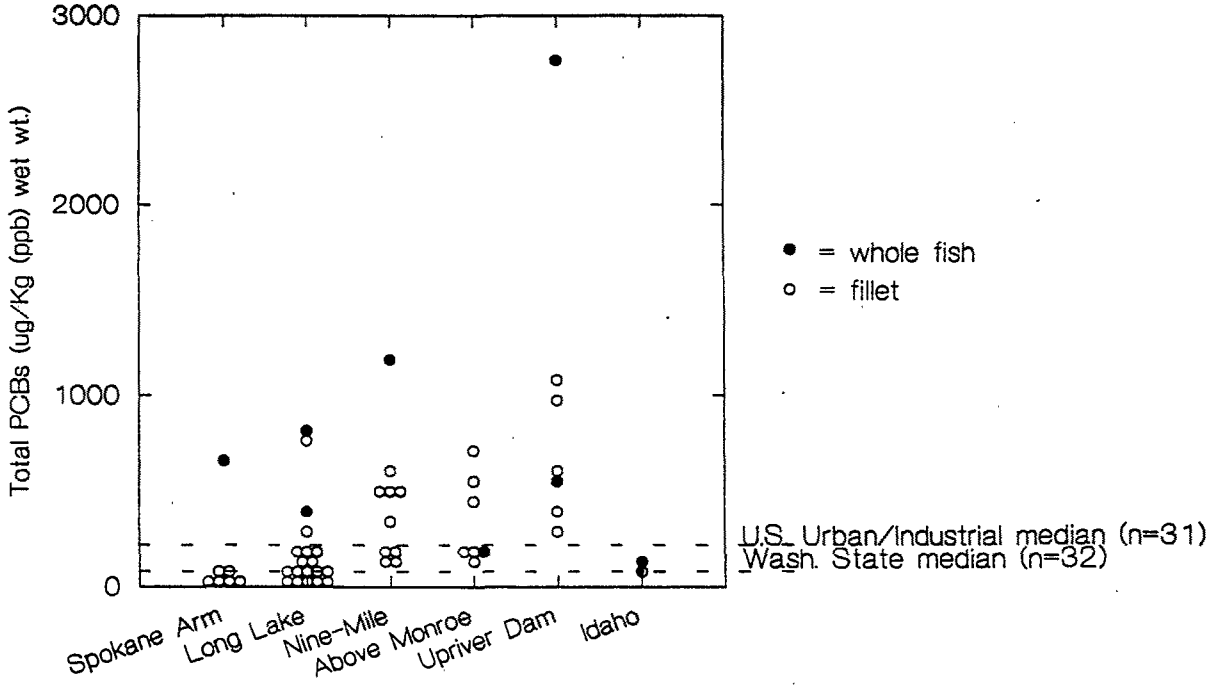

Fig. 10. Total PCBs in Spokane River Fish, 1993-94 Data

Rainbow trout collected between Upriver and Monroe St. dams had much lower PCB concentrations than the mountain whitefish obtained in this area (111 - 164 ppb vs. 449 - 725 ppb; Table 2). All trout included in these samples appeared to be wild rather than planted fish (i.e., no adipose fin clip). Lipid (fat) levels were low compared to rainbow trout from other parts of the river (1.1 - 1.2% vs 1.7 - 5.4%). Lipids are a major factor regulating uptake of PCBs and other lipid soluble chemicals. In general, the higher the lipid content, the higher the concentration of PCBs retained in the organism.

When total PCB concentrations are normalized to percent lipid*, results compare more closely between trout (10,000 - 13,700 ppb, lipid basis) and whitefish (8,200 - 15,800 ppb, lipid basis) in this reach. The relatively low concentration of total PCBs in the whole fish sample from this area (210 ppb) also appears due to an unusually low lipid level (Table 3); the lipid normalized concentration is 16,750 ppb.

Fish samples from the Little Spokane River had total PCB concentrations of 145 - 440 ppb. These concentrations are unexpectedly high, as no sources of PCBs had been identified in this drainage. Unlike main stem samples, PCB-1260 was the predominant mixture identified, accounting for 59 - 74% of total PCBs (Figure 11). The elevated PCB concentrations coupled with the unusual preponderance of -1260 may indicate the presence of a source of this mixture to the Little Spokane.

* lipid normalized conc. = (wet weight conc. / % lipid) x 100

1993 vs. 1994 Fish Samples

A number of the 1994 fish samples from the upper river had lower PCB concentrations than when the same species were analyzed in 1993. Table 4 compares results for species sampled from the same site in both years.

Total PCBs in 1994 samples of rainbow trout and largescale suckers above Upriver Dam, rainbow and mountain whitefish in Nine-Mile reservoir, and mountain whitefish in upper Long Lake were lower than 1993 results by 50% or more, on average. These species were among the most contaminated in 1993. Although the 1994 levels in trout and suckers remain elevated, the more recent results on whitefish from these two areas approach the state median for total PCBs.

The data were corrected for lipid content to see if this could explain the difference (Table 4). Results showed lipid-based concentrations were also lower in 1994 than 1993. When size of fish used in the samples is compared (Figure 12), Long Lake whitefish are seen to have been much smaller in 1994, perhaps explaining the results

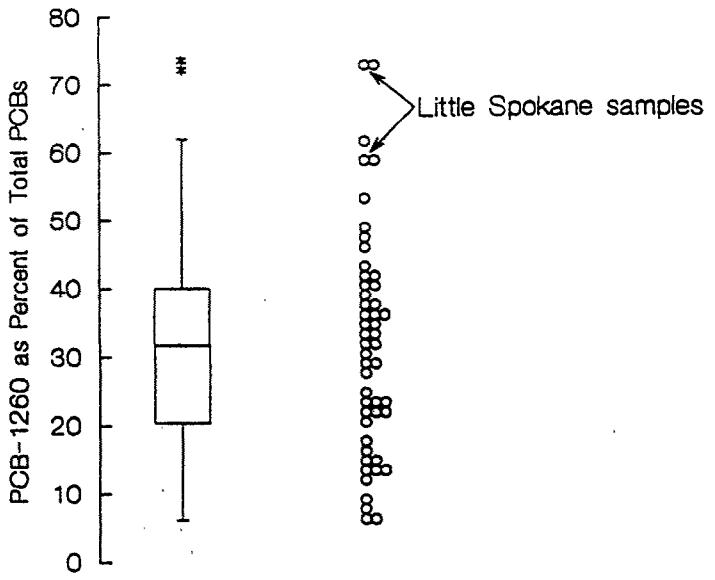

Figure 11. Percent PCB-1260 in 1993-94 Fish Samples

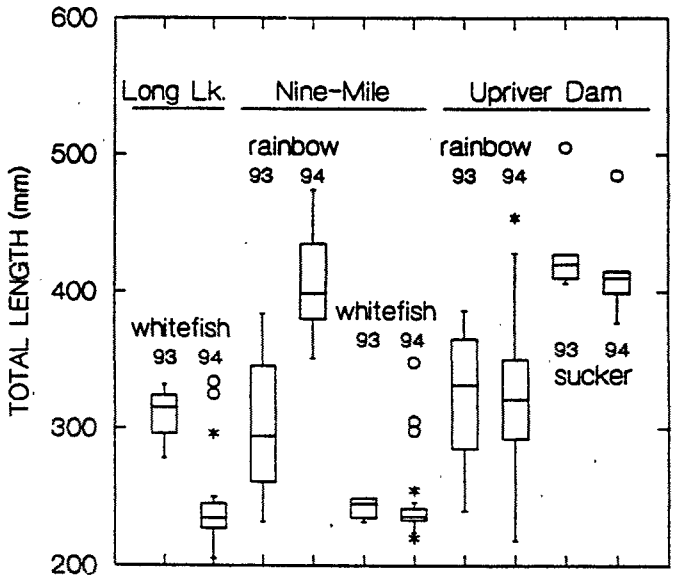

Fig 12. Size Comparison of Fish Sampled in 1993 & 1994

Note: In the box and whisker plots above, the median value is shown as a horizontal line and the box represents the interquartile range (25th - 75th percentile); a vertical line (whisker) extends 1.5 times the interquartile range. Outside and far outside values are plotted beyond the whiskers as asterisks and circles, respectively.

Table 4. Comparison of Total PCBs in Spokane River Fish Species Sampled in 1993 & 1994 (ug/Kg (ppb))

Species	Sample Type	Total PCBs (wet wt. basis) 1993	Total PCBs (wet wt. basis) 1994	Total PCBs (lipid normalized) 1993	Total PCBs (lipid normalized) 1994
		Idaho			
Largescale Sucker	Whole	96	152	1,330	2,760
		Trent Rd. to Upriver Dam			
Rainbow Trout	Fillet	950	385	55,900	13,300
" "	"	1,084	605	57,100	22,800
" "	"	-	280	-	7,570
Largescale Sucker	Whole	2,775	531	64,500	14,800
		Nine-Mile Reservoir			
Mountain Whitefish	Fillet	522	120	19,300	1,740
" "	"	-	111	-	1,320
" "	"	-	185	-	2,800
Rainbow Trout	Fillet	474	320	17,600	5,930
" "	"	505	205	17,400	6,830
" "	"	-	589	-	11,300
		Upper Long Lake			
Mountain Whitefish	Fillet	780	150	22,300	4,170
" "	"	-	180	-	5,290
" "	"	-	71	-	3,740
		Lower Long Lake			
Yellow Perch	Fillet	9.4	9	4,700	4,500
" "	"	-	16	-	8,000
" "	"	-	16	-	8,000
Largemouth Bass	Fillet	97	94	16,200	9,400
		-	104	-	9,450
Largescale Sucker	Whole Fish	410	820	17,800	24,100
		Spokane Arm			
Walleye	Fillet	15	31	3,750	3,440
"	"	-	58	-	7,250
"	"	-	50	-	5,560

= 1994 concentrations lower than 1993 by 50% or more (on average)

for this site. The size of fish used in all other 1994 samples, however, was similar to or larger than in 1993.

Figure 13 plots only the 1994 data for main stem fish samples. Whereas half the 1993-94 samples exceeded the 1987 U.S. urban/industrial median for total PCBs, only about 25% of the 1994 samples were greater than this value. Being a larger sample size, the 1994 results may be more representative of PCB levels in the river. On the other hand, as described later in this report, actions were taken during 1992-93 to correct PCB problems at three industrial sites located on the river. These improvements would be expected to have reduced input of PCBs to the river which may, in turn, be reflected in the lower level of contamination seen in 1994.

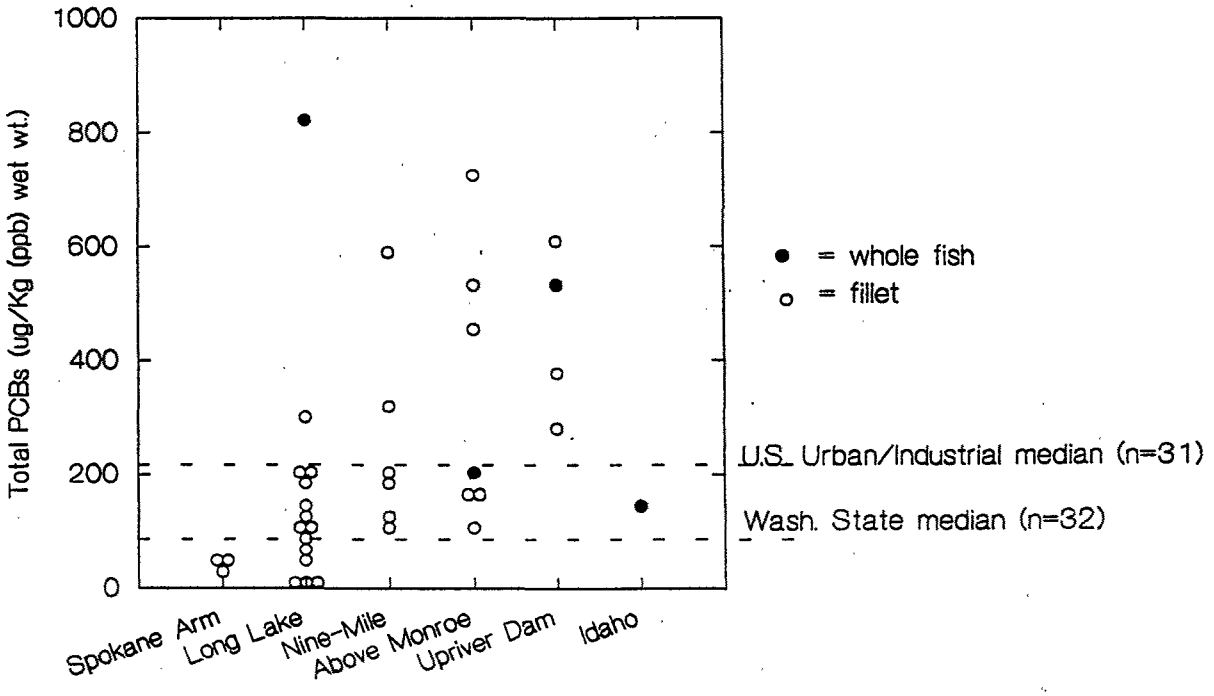

Fig. 13. Total PCBs in Spokane River Fish, 1994 Data Only

PCB Concentrations in Sediment Samples

PCB-1248, -1254, and 1260 were also detected in Spokane River sediments (Table 5). Whereas PCB-1254 was the major component in fish samples, -1248 was the mixture most frequently detected in the sediments. Of the 18 sites where sediments were analyzed, PCB-1248 was detected at 15 (83%), while -1254 and -1260 were detected at only 5 sites each (28%).

Figure 14 shows the distribution of PCBs in the sediments. At sites where more than one sample was collected or where duplicates were analyzed, only detected values were plotted and duplicate results averaged. Results on samples collected for bioassay are not shown, these having included deeper, and therefore older, layers of material.

PCB-1248 was detected at all sites except in Idaho and the Spokane Arm. PCB-1254 and -1260 were primarily detected in samples collected in Idaho and the lower river. A region of elevated concentrations of PCB-1248 was found in the sediments between Myrtle Point five miles above Upriver Dam, and Monroe St. Dam.

Elevated concentrations of total PCBs ranging from 210 - 3,000 ppb were detected in sediments from three areas: just above the state line at Pleasant View Rd.; site #1 just above Upriver Dam; and two sites above Monroe St. Dam between Division St. and Trent Ave. Concentrations of total PCBs in sediments from other areas were less than 67 ppb and averaged approximately 20 ppb.

The sediment data were normalized to TOC to determine if other patterns might be present that were obscured by differences in the organic content of the sediments (Figure 15). Organic matter can serve as a sink or transport medium for PCBs. The results reveal no additional sites where PCBs appeared unusually elevated.

One of the two samples collected at Pleasant View Rd., Idaho during 1994 had 210 ppb of PCB-1254. This is the only site where an elevated concentration of -1254 was detected. The only other PCBs found in Idaho sediments were trace amounts (6.8 - 12 ppb) of PCB-1254 and -1260 above Post Falls Dam.

Samples at Upriver Dam site #1 were collected in 18 - 21 feet of water off the north river bank about 1/4 mile upstream of the dam (see Figure 7). High PCB-1248 concentrations of 2,400 - 3,000 ppb were detected here in 1993 and 1994. A deeper sample collected for bioassay in 1994 had 4,500 ppb.

Sediments at this site consisted of a dark, fibrous material that did not resemble natural river sediments and appeared to be confined to a restricted area. A sample collected on the opposite side of the river (site #2) had only 20 - 26 ppb of PCB-1248 (Table 5).

Table 5. PCBs in Spokane River Sediments Collected in 1993 & 1994 (ug/Kg (ppb) dry wt.)

Sample Number	Site Name (river mile)	Month/ Year	TOC (%)	Fines* (%)	PCB-1248	PCB-1254	PCB-1260	Total PCBs
				Idaho				
93-318236	Ab. Post Falls Dam (102.6)	7/93	2.7	26	3.1 U	**6.8**	**12**	**19**
94-328406	Ab. Post Falls STP (101.7)	8/94	2.6	16	16 U	16 U	16 U	nd
94-218090	Pleasant View Rd. (99.0)	5/94	na	na	92 U	**210**	92 U	**210**
94-328408	" " "	8/94	2.6	7	15 U	15 U	15 U	nd
"	(duplicate analysis)	"	na	na	16 U	16 U	16 U	nd
				State Line to Upriver Dam				
94-328403	State Line (94.8)	8/94	5.2	26	**17**	18 U	18 U	**17**
"	(duplicate analysis)	"	na	na	17 U	17 U	17 U	nd
94-318270	Myrtle Point (84.5)	8/94	0.4	1	**5.3**	4.6 U	4.6 U	**5.3**
94-318271	1/2 mi. bw. Myrtle Pt. (84.0)	8/94	1.1	1	**67**	29 U	29 U	**67**
94-318272	Beach bw. Myrtle Pt. (83.4)	8/94	2.2	6	**170**	30 U	30 U	**170**
94-318275	Boulder Beach (81.5)	8/94	1.1	5	**11**	4.9 U	4.9 U	**11**
94-218093	" " "	5/94	na	na	10 U	10 U	10 U	nd
93-318235	Upriver Dam #1 (80.5)	7/93	11	34	**3000 J**	1000 U	140 U	**3000 J**
94-318237	" " " "	8/94	11	22	**2400 J**	76 U	**53 J**	**2453 J**
"	(duplicate analysis)	"	na	na	**2700 J**	160 U	160 U	**2700 J**
94-328001	Upriver Dam #1 (80.5)**	8/94	13	33	**4500**	190 U	190 U	**4500**
94-318274	Upriver Dam #2 (80.5)	8/94	2.2	10	**20 J**	6 U	6 U	**20 J**
"	(duplicate analysis)	"	na	na	**26 J**	30 U	30 U	**26 J**
				Upriver Dam to Monroe St. Dam				
94-328400	Bw. WWP Yard (78.7)	8/94	2.2	2	**3.6 J**	5.1 U	5.1 U	**3.6 J**
94-328401	Mission Bridge (76.6)	8/94	0.4	2	**31**	4.8 U	4.8 U	**31**
94-328402	Old Bridge (75.7)	8/94	1.0	na	**13**	5.5 U	5.5 U	**13**
94-328404	Nr. Post Office (75.4)	8/94	0.8	3	**300**	50 U	50 U	**300**
94-328405	Ab. Division St. (74.9)	8/94	2.5	6	**190**	50 U	**200**	**390**

Table 5 . (continued)

Sample Number	Site Name (river mile)	Month/ Year	TOC (%)	Fines* (%)	PCB-1248	PCB-1254	PCB-1260	Total PCBs
				Nine-Mile Reservoir				
93-318234	Deep Creek (58.7)	7/93	1.8	6	**3** J	**3.1**	**3** J	**9.1** J
				Long Lake				
93-318231	DNR Campground (39.0)	7/93	3.9	98	**10** J	**21** J	**22**	**53** J
"	(duplicate analysis)	"	na	na	**10** J	**20** J	**14**	**44** J
94-328002	DNR Campground (39.0)**	8/94	0.8	19	**21**	10 U	10 U	**21**
				Spokane Arm				
93-318230	Porcupine Bay (13.2)	7/93	1.8	67	17 U	**8.5** J	**5.3** J	**13.8** J
94-328003	" " " **	8/94	1.8	94	**35**	21 U	21 U	**35**

* silt + clay fractions (<0.004-0.063 mm)
**top 5 cm surface layer (for bioassay) vs. 2 cm in other samples
U = not detected at or above reported value (i.e., less than)
J = estimated value
na = not analyzed
nd = not detected

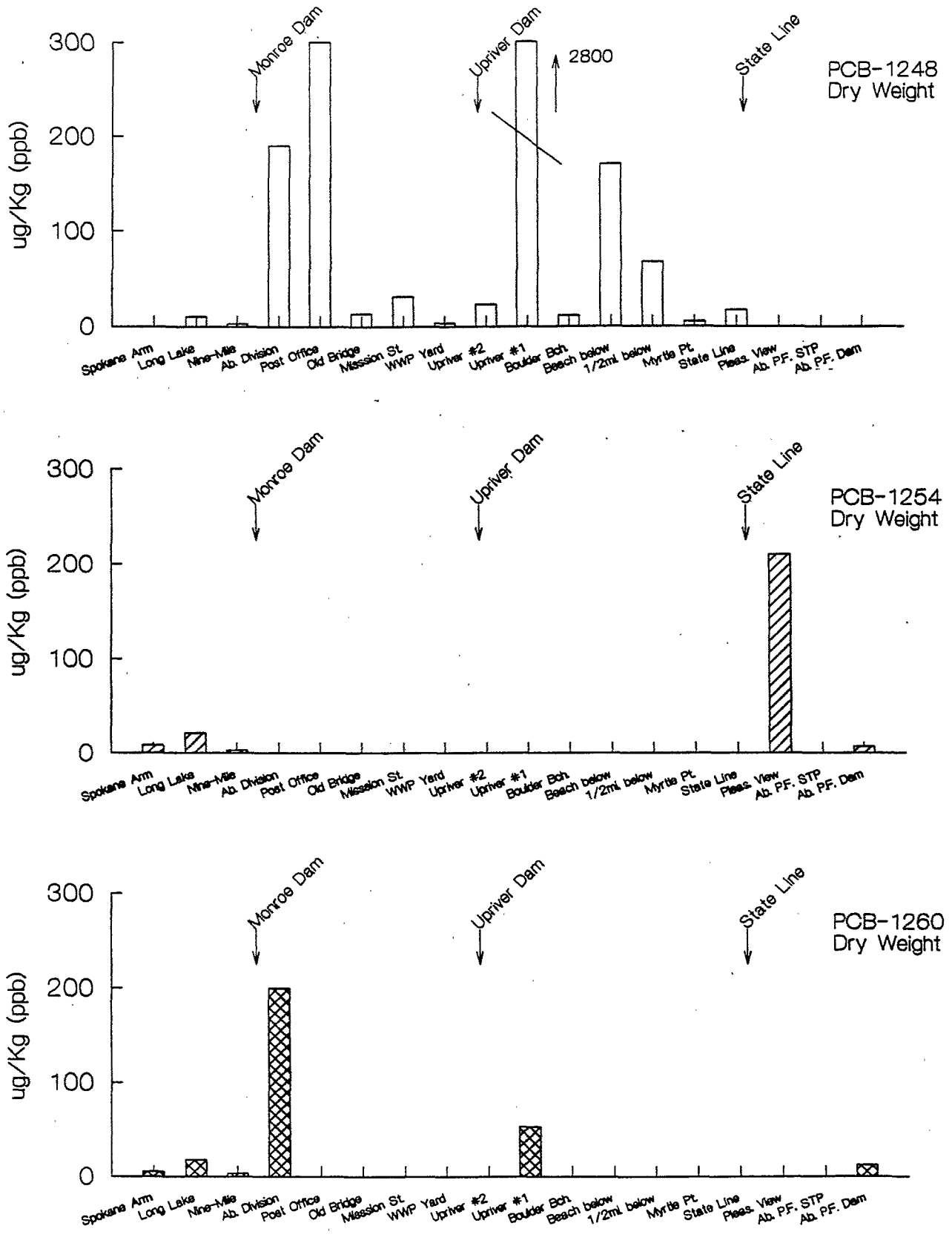

Fig. 14. PCBs in Spokane River Sediment Samples, 1993-94 Data

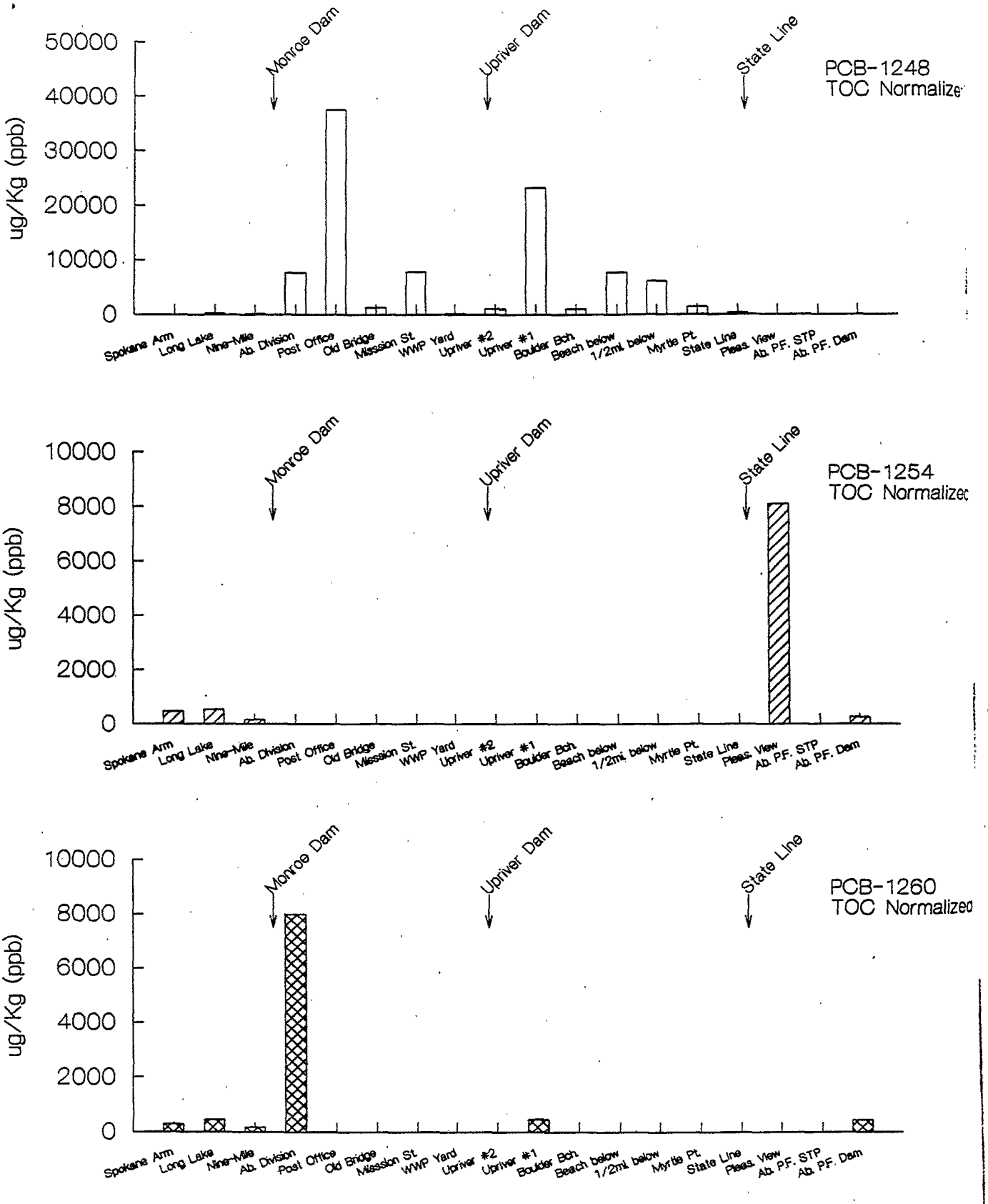

Fig. 15. Spokane River Sediment PCB Data Normalized to TOC

Manchester Laboratory conducted a microscopic evaluation of the material at Upriver Dam site #1 and #2 (Huntamer, 1995-draft). Site #1 contained significant amounts of charcoal particles and partially carbonized plant material. Similar but much lesser amounts of this material could be seen at site #2. PCB analysis of the fines and charcoal fractions showed that the PCBs were concentrated in the charcoal. It is not known if the charcoal was contaminated prior to being deposited or has absorbed PCBs while in place. As this material decays, PCBs may become available to the river.

Kaiser has reported results for a sediment core obtained just downstream of Upriver Dam site #1 (Hart Crowser, 1995). Concentrations of PCB-1248 peaked at 14,700 ppb at a depth of 25 - 30 cm. Concentrations gradually decreased moving up the core from 5,608 ppb at 20 - 25 cm to 1,010 ppb at the surface (0 - 5 cm), indicating PCB inputs have been decreasing over time.

The sediment sample off the south river bank above Division St. had a total PCB concentration of 390 ppb -- 190 ppb of PCB-1248 and 200 ppb of PCB-1260 (see Figure 8). This is the only location where PCB-1260 was elevated in the sediments. The next upstream sample also had an elevated concentration of 300 ppb PCB-1248, but -1260 was not detectable. The upstream sample was collected off the Postal Terminal, opposite and slightly above the old Inland Metals operation.

Ecological Assessment

[As noted at the beginning of this report, human health concerns are to be addressed in a separate evaluation by the Washington State Department of Health.]

Implications for Fish and Wildlife

Several agencies have developed recommendations for PCB concentrations in fish to protect aquatic life and fish-eating wildlife (Table 6). The EPA water quality criterion for chronic exposure to PCBs in freshwater is based on a dietary level of 640 ppb total PCBs which caused adverse effects to mink, a species sensitive to PCBs. EPA cautions this value may be too high because the no-effect-level (NOEL) was not determined (EPA, 1980a).

The National Academy of Sciences (1973) recommended 500 ppb total PCBs as a maximum permissible tissue concentration for any aquatic organism. This value was derived from consideration of thresholds for egg mortality in salmon.

More recent recommendations have set lower values as being protective of fish-eating birds and mammals. The state of New York proposed a concentration of 110 ppb total PCBs to protect wildlife populations from carcinogenic and non-carcinogenic effects of

PCBs (Newell et al., 1987). This criterion was derived from results of laboratory feeding studies on a variety of species, including the same study (Platonow and Karstud, 1973) that determined 640 ppb as the lowest observed effect level (LOEL) for PCBs in mink. The criterion incorporates uncertainty factors in converting LOELs to NOELs for non-carcinogenic effects, and a cancer risk level of 1-in-100. The International Joint Commission has set a comparable goal of 100 ppb total PCBs in Great Lakes fish (IJC, 1975).

Table 6 . Environmental Criteria and Guidelines for PCBs in Fish Tissue
(ug/Kg (ppb) wet wt.)

Total PCBs	Criteria/Guideline	Source	Reference
640 (diet)	Reproduction of mink impaired	Basis of EPA chronic water quality criterion	EPA (1980a)
500	Not to be exceeded to protect aquatic life	Nat. Academy Sciences Recommendation	NAS (1973)
110	To protect fish-eating birds and mammals	Niagara River Fish Flesh Criteria	Newell et al., (1987)
100	To protect fish-eating birds and mammals	IJC Great Lakes goal	IJC (1975)

The New York criterion of 110 ppb total PCBs is the most recent guideline available and is based on the most data. The New York methodology was recently selected to develop Canadian tissue residue guidelines for protecting wildlife (Environment Canada, 1994-draft). A total PCB concentration of 110 ppb in fish tissue appears the best value currently available for assessing the hazards PCBs pose to fish-eating wildlife of the Spokane River.

Many of the fish samples collected in the Spokane River during 1993-94 substantially exceeded 110 ppb total PCBs. The eight whole fish samples analyzed downstream of the state line had total PCB concentrations ranging from 201 ppb to 2,780 ppb (above Upriver Dam, 1993 sample). The extreme high result at Upriver Dam aside, the mean value for total PCBs in Spokane River whole fish was 675 ppb. This concentration is at a level that adversely affected mink and is likely to adversely affect other aquatic organisms and their predators.

Seventy-five percent (14 of 19) of the edible tissue samples collected from behind Upriver Dam to Nine-Mile reservoir exceeded the 110 ppb level by a factor of two or more. Higher concentrations would be expected had these species been analyzed whole.

Potential for Sediment Toxicity

Relatively little information is available to determine where PCB concentrations begin to adversely affect animals living on or in the sediments. The most complete numerical criteria and only comprehensive list for freshwater based on biological effects are the Ontario Provincial sediment quality guidelines (Persaud et al., 1993). These values were derived from field data on sediment chemistry, and the abundance and diversity of benthic invertebrates.

Table 7 summarizes the Ontario guidelines for PCBs. The severe effects levels are normalized to TOC. For a given concentration of PCBs in the sediments, increased TOC content decreases the toxicity due to greater sorption and, therefore, decreased bioavailability.

Table 7. Ontario Sediment Quality Guidelines for PCBs (ppb)

PCB	Concentration	Units	Guideline
Total PCBs	10	ug/Kg, dry wt.	No Effect Level
PCB-1248	30	ug/Kg, dry wt.	Lowest Effect Level:
PCB-1254	60	ug/Kg, dry wt.	tolerated by most
PCB-1260	5	ug/Kg, dry wt.	benthic organisms
Total PCBs	70	ug/Kg, dry wt.	
PCB-1248	150,000	ug/Kg, TOC	Severe Effect Level:
PCB-1254	34,000	ug/Kg, TOC	detrimental to most
PCB-1260	24,000	ug/Kg, TOC	benthic organisms
Total PCBs	530,000	ug/Kg, TOC	(TOC normalized)

source: Persaud et al. (1993)

Comparison of these guidelines to concentrations measured in Spokane River sediments indicates the PCB levels at most sites are not likely to cause significant toxicity. The samples from Nine-Mile reservoir, Long Lake, and the Spokane Arm did not have toxic concentrations of PCBs (Table 5). Five sites between the state line and Monroe St. Dam exceeded lowest effects levels for one or more PCB mixtures. However, TOC normalized concentrations were never more than one third of severe effects levels at these sites. Ninety percent of the sediment sampling sites in the Spokane River (16 of 18) had PCB concentrations no more than 7% of levels found to severely affect bottom-dwelling animals.

Bioassays of sediments from three of the 1994 sampling sites did show evidence of toxicity but this appears to be due to metals (Table 8). The Hyalella bioassay determines ten-day survival of a small, amphipod crustacean that lives on or in the sediments. The Microtox assay measures the reduction in light production caused by enzyme inhibition in the luminescent bacterium Photobacterium phosphoreum. This test was run on a de-ionized water extract of the sediments.

As indicated in Table 8, concentrations of zinc, lead, and cadmium at the Upriver Dam #1 site, and zinc and cadmium at the Spokane Arm site exceeded severe effects levels. The elevated concentrations of polyaromatic hydrocarbons, 4-methylphenol, and retene in the Upriver Dam sample are associated with the charcoal particles at this site. Although bioassay of the Long Lake sediment did not show toxicity, metals concentrations in other samples collected at the same location in 1992 and 1993 have been at toxic levels (Serdar et al., 1994; Johnson et al., 1994a).

PCBs Detected at Industrial/Municipal Facilities

Table 9 summarizes results from PCB analysis of sludges and other solids collected during source investigations in 1994. PCB-1248 and -1260 were detected at a number of facilities. PCB-1254 was not detected in Ecology samples but has been identified in samples analyzed by other parties. Findings and supplemental PCB data for each facility are described below:

Kaiser Trentwood

This facility is an aluminum rolling mill and metal finishing plant. Wastewater is discharged through a treatment lagoon to the Spokane River (outfall #001). Inputs to the lagoon consist of effluents from the industrial wastewater treatment facility (#002), domestic treatment facility, non-contact cooling water, and stormwater runoff.

Samples for Ecology's investigation were collected in May (sludge and other solids) and August (effluents), 1994. No PCBs were detected in sludge collected from the

Table 8. Summary of Toxicity and Chemical Data on Spokane River Sediments, 1994

Location: / Sample Number:	Upriver Dam (328001)	Spokane Arm (328003)	Long Lake (328002)
BIOASSAYS:			
Hyalella (10-day survival)	50%	80%	92%
Microtox (EC50)	28%	41%	>53%
CHEMISTRY:			
PCB-1248 (ug/Kg (ppb) dry wt.)	**4500**	**35**	**21**
PCB-1254 "	190 U	21 U	10 U
PCB-1260 "	190 U	21 U	10 U
Total PCBs "	**4500**	**35**	**21**
Total PCBs (mg/Kg TOC (ppm))	**34.6**	**1.9**	**2.6**
Zinc (mg/Kg (ppm) dry wt.)	**4050***	**1180***	**520**
Lead "	**542***	**81**	**42**
Cadmium "	**40***	**9.1***	**3.9**
Total PAH (ug/Kg (ppb) dry wt.)	**2757**	**27**	**466**
4-methylphenol ** "	**3590**	nd	**599**
retene** "	**6020**	**77**	**57**
TOC (%)	13	1.8	0.8
% Fines (silt + clay fractions)	33	94	19

[ ] = significant effect (>95%) compared to Long Lake
EC50 = effective concentration, 50% light reduction
PAH = polyaromatic hydrocarbons
U = not detected at or above reported value (i.e., less than)
nd = not detected
* at or above Ontario severe effect level (Persaud et al., 1993)
** sediment guidelines not available

Table 9 . PCBs in Solids Collected from Industrial / Municipal Facilities on the Spokane River in 1994
(ug/Kg (ppb) dry wt.)

Sample Number	Facility	Sample Description	Date	TOC (%)	PCB-1248	PCB-1254	PCB-1260	Total PCBs
218082	Kaiser Trentwood	Sludge, industrial side	5/25	3.7	110 U	110 U	110 U	nd
218084	" "	Lagoon sediment	5/25	22	**7700**	400 U	**320 J**	**8020 J**
218086	" "	Lagoon O/W skimmings	5/25	na	**1100**	68 U	68 U	**1100**
218088	Spokane Industrial	Sludge, oxidation ditch*	5/25	44	**12000**	2000 U	2000 U	**12000**
318166	Park	" " "	7/31	26	**11000**	1720 U	1720 U	**11000**
318174	Liberty Lake STP	Sludge, aerobic digester	8/03	35	**4400**	340 U	340 U	**4400**
318169	Spokane STP	Sludge, belt filter press	8/02	na	**510**	210 U	210 U	**510**
328407	Post Falls STP	Sludge, belt filter press	8/10	35	**84**	63 U	**140**	**224**
218080	Near Former Site of Inland Metals	Soil adjacent to river	5/25	4.8	**4700**	440 U	**3900**	**8600**
218092	WWP Yard	Soil in drainage to river	5/26	na	**11 J**	7.7 U	**14**	**25 J**

* inactive
U = not detected at or above reported value (i.e., less than)
J = estimated value
na = not analyzed
nd = not detected

industrial treatment facility (110 ppb detection limit). However, the August sample of the industrial effluent (#002) had 0.034 ppb of PCB-1260 (Table 10).

Both PCB-1248 (7,700 ppb) and -1260 (320 ppb) were detected in Kaiser lagoon sediments, with -1248 also being detected in surface skimmings from the lagoon oil/water separator (1,100 ppb). Only PCB-1248 was detected (0.021 ppb) in the lagoon discharge to the Spokane River (#001). These results are in close agreement with final effluent concentrations of 0.014 - 0.021 ppb PCB-1248 reported by Kaiser for the period August - October, 1994 (Hart Crowser, 1995).

In the spring of 1992 Kaiser bypassed the lagoon, de-watered and disposed of the sludge. The lagoon was re-lined and put back into service in September 1993 (Hallinan, 1995). Ecology data indicate Kaiser's discharge of PCBs to the river was reduced between 1990 and 1994 (Table 11). The 1990 data are from a pilot study of effluent centrifugation (Ecology, unpublished) and a Class II inspection conducted at the same time (Hallinan et al., 1991).

Concentrations of PCB-1248 in solids samples collected in 1994 were an order of magnitude lower than in solids sampled in 1990. The calculated daily load of PCB-1248 to the river was reduced by a factor of at least three between the 1990 and 1994 sampling events. The load calculated for 1990 is for the particulate fraction only, and therefore underestimates the total load because dissolved PCBs were not measured.

Kaiser believes the source of PCBs at the Trentwood facility to be hydraulic fluid used in the early 1970's (P. Blau, personal communication). PCB contamination of the soils at Kaiser was discovered in 1991. Some of the PCB-contaminated soils have been excavated. In 1992, PCBs were detected in samples from a layer of petroleum floating on the groundwater beneath the facility. Monitoring wells installed by Kaiser indicate the PCB-contaminated oil has not reached the Spokane River (K. Stoffel, personal communication).

Spokane Industrial Park (SIP)

High concentrations of PCB-1248 (11,000 - 12,000 ppb) were found in Ecology's 1994 samples of sludge from SIP's inactive oxidation ditch. This sample was split with Pentzer Development Corp., owners of SIP, who reported 24,000 ppb of PCB-1248 (Dethloff, 1995). Analysis reported by Pentzer on a separately collected composite of seven individual sludge samples showed 3,200 ppb of PCB-1254. The analyst noted that the "chromatographic pattern was generally consistent with either Aroclor-1248 or Aroclor-1254, however, the unknown was identified as Aroclor-1254 because it contained a series of peaks that are found only in Aroclor-1254..." (Dethloff, 1995).

Table 10. PCB Analysis of Effluents from Kaiser Trentwood and Spokane Industrial Park, 1994 (ug/L (ppb))

Sample Number	Facility	Date	TSS (mg/L)	TOC (mg/L)	Flow (mgd)	PCB-1248	PCB-1254	PCB-1260	Total PCBs
318155	Kaiser Trentwood (#001)	8/01	2	3.4	28.8	**0.021**	0.009 U	0.009 U	**0.021**
318156	" " (#002)	8/01	na	na	0.14	0.009 U	0.009 U	**0.034**	**0.034**
318157	Spokane Industrial Park	7/31	2	1.6	*	0.009 U	0.009 U	0.009 U	nd
318179	" " "	8/04	22	13.9	*	0.031 U	0.031 U	0.031 U	nd
318153	Kaiser field blank	7/31	na	na	-	0.009 U	0.009 U	0.009 U	nd
318154	SIP field blank	8/01	na	na	-	0.009 U	0.009 U	0.009 U	nd

* to Spokane STP
mgd = million gallons per day
U = not detected at or above reported value (i.e., less than)
na = not analyzed
nd = not detected

Table 11. Ecology Data on PCB-1248 in Kaiser Lagoon and Final Effluent

Sample Type	1990	1994
Lagoon Sediment (ug/Kg (ppb) dry wt.)	83,000	7,700
Lagoon Skimmings (ug/Kg (ppb) dry wt.) (O/W separator)	na	1,100
#001 Particulates (ug/Kg (ppb) dry wt.)	32,000	na
#001 Effluent (ug/L (ppb))	0.095 (particulate fraction)	0.021 (whole effluent)
PCB-1248 Load to Spokane River (gm/day)	8.1* (particulates only)	2.3** (whole effluent)

* @ 22.5 mgd (5/21-22/90)
**@ 28.8 mgd (8/01/94)
na = not analyzed

Two grabs of SIP effluent were analyzed by Ecology in 1994 (Table 10). Separately collected effluent samples were provided to Pentzer at the same time. No PCBs were found in Ecology samples at detection limits of 0.009 - 0.031 ppb. Pentzer reported 0.026 ppb of PCB-1254 in the August 4 sample, and no PCBs detected in the July 31 sample (0.020 ppb detection limit). An Ecology Class II inspection conducted during May 1992 (Hoyle-Dodson, 1993) detected no PCBs in the effluent, but the detection limit was high (1 ppb). No sludge was available for analysis at that time.

SIP stopped treating and discharging their wastewater to the Spokane River in December 1993 when it was diverted to the City of Spokane sewage collection system. The sludge was removed from the oxidation ditch in September - October, 1994 and sent to a hazardous waste disposal facility in Arlington, Oregon (D. Nichols, personal communication).

Sewage Treatment Plants

PCB-1248 was detected in sludge samples from the Liberty Lake (4,400 ppb), Spokane (510 ppb), and Post Falls (84 ppb) treatment plants. The Post Falls sludge also had some PCB-1260 (140 ppb).

PCB data on sludge samples from Ecology Class II inspections of other Washington STPs were reviewed to put these results in perspective (Appendix E). Of 23 plants analyzed since 1988, PCBs were detected at only two facilities. Concentrations of total PCBs were 720 and 1,900 ppb. Although detection limits for some of these investigations were inadequate to detect PCB concentrations in the range of the Post Falls or Spokane plants, concentration levels on the order of Liberty Lake's sludge should not have escaped detection. An EPA national sewage sludge survey detected PCBs in only 15% of the samples (EPA, 1990c).

No other PCB data are available on the Liberty Lake or Post Falls STPs. An Ecology Class II Inspection (Hallinan, 1989) of the Spokane STP during September 1988 detected no PCBs in the sludge (660 ppb detection limit) or effluent (0.02 ppb detection limit). PCB data obtained through the City of Spokane, Department of Wastewater Management show that of five sludge and six effluent samples analyzed from 1991 - 1994, 370 ppb of PCB-1254 was detected in one 1992 sludge sample. Detection limits were 80 - 380 ppb in sludge and 0.02 - 2 ppb in effluent.

Old Inland Metals Site

Inland Metals was a scrap metal salvaging operation near 3rd and Brown Streets. PCBs (variously reported as -1242, -1254, -1260, and -1268) were detected in soils from this site in 1985 at concentrations ranging up to 12,000 ppb (Carter, 1992). The salvage

operation closed in 1986 and the property was sold for development. Cleanup was begun in 1987 and completed in early 1992.

Soil sample results in August 1992 showed concentrations of 36 - 410 ppb total PCBs. As these concentrations were below the residential cleanup level of 1,000 ppb and far below the industrial cleanup level of 10,000 ppb (WAC 173-340 WAC; Model Toxics Control Act), Ecology recommended that it be removed from the Hazardous Sites List (Carter, 1992).

The soil sample for the 1993-94 PCB investigation was collected along the river shoreline in what appeared to have been a drainage area from the old Inland Metals site (Figure 16). Results showed elevated concentrations of PCB-1248 (4,700 ppb) and -1260 (3,900 ppb). All or part of the area sampled looked to be under water during high flow.

Washington Water Power Co. (WWP) Yard

This WWP yard is also known as the Beacon Storage Yard. Yard runoff collects to the middle and flows through a culvert to the river bank. Soil was collected at the bottom of the bank. PCB-1248 and -1260 were detected but at trace levels of 11 - 14 ppb.

PCB Concentrations in River Water

Particulate PCBs

Table 12 shows the results of analysis on the suspended particulate samples collected in the upper river at Barker Road and Plante's Ferry Park (see Figure 9). The Barker Road site is approximately 1.3 miles below the Liberty Lake STP outfall; Plante's Ferry Park is approximately 1.3 miles below the Kaiser Trentwood outfall.

Table 12. PCB Analysis of Spokane River Suspended Particulate Samples, 1994 (ug/Kg (ppb) dry wt.)

Sample Number	Location (river mile)	Dates	Volume Sampled (L)	TSS (mg/L)	Sample Wt. (gm)	PCB-1248	PCB-1254	PCB-1260	Total PCBs
318158	Barker Rd. (90.5)	7/30-8/1	8,895	1-2 (n=7)	-	67 U	67 U	67 U	nd
318172	Plante's Ferry (84.7)	8/2-8/5	22,207	<1-1 (n=10)	109	**220**	70 U	70 U	**220**

U = not detected at or above reported value (i.e., less than)
nd = not detected

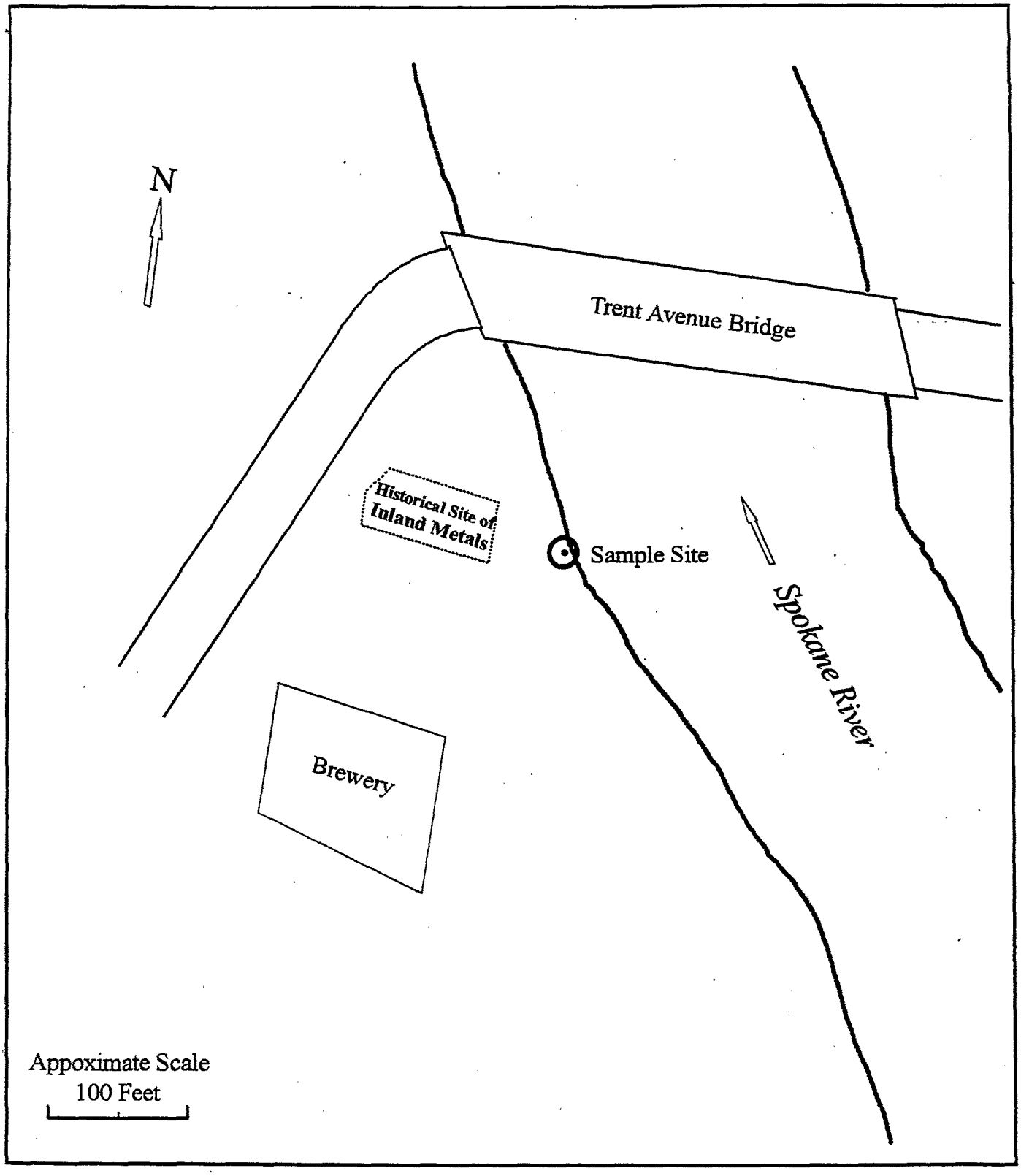

Figure 16. Location of Soil Sample Collected Near Old Inland Metals Site, May 25, 1994.

No PCBs were detected in the Barker Road sample at a detection limit of 67 ppb. The downstream sample at Plante's Ferry had 220 ppb of PCB-1248; PCB-1254 and -1260 were below the detection limit (70 ppb). Total suspended solids (TSS) concentrations were very low at both sampling sites but were lower in the downstream sample, indicating the detection of PCBs was probably not due to bottom sediments being entrained in the water column.

Based on the river flow at the time of collection (see below), the PCB-1248 load in the river at Plante's Ferry was 0.15 gm/day. The load at Barker Road was less than 0.07 gm/day.

Soluble PCBs

Low concentrations of PCB-1248 were detected in SPMDs* deployed at the state line and at Plante's Ferry Park (Table 13). These results are for the total mass of -1248 in each SPMD. Equations 1 and 2 can be used to obtain an estimate of dissolved PCB concentrations at these two sites (Huckins et al., 1990; 1993).

1) $R_{SC} = R_S(1-F_I)$

where R_{SC} is the field sampling rate of the SPMD for PCBs, corrected for biofouling impedance (F_I) during deployment.

2) $C_W = C_L V_L / R_{SC} T$

where C_W is the estimate of the average PCB concentration in water, C_L is the total mass of PCBs in the SPMD, V_L is the volume of triolein, and T is duration of deployment. Values of R_S have been determined experimentally for 2,2',5,5'-PCB, but not for PCB mixtures. Because PCB-1248 is dominated by tetrachlorobiphenyls (Hammond et al., 1972), 2,2',5,5'-PCB was used as a model. Extreme biofouling can reduce sampling rates of the SPMD by 30-40%, F_I was set at 0.2 (J. Huckins, personal communication).

* This sampler further described in Appendix A

Table 13. PCB Analysis of SPMDs Deployed in Upper Spokane River, 1994 (total mass in ug)

Sample Number	Location (river mile)	Dates	PCB-1248	PCB-1254	PCB-1260	Total PCBs
328442	State Line (96.5)	8/9-9/14	**0.1** NJ	0.1 U	0.1 U	**0.1** NJ
328440	Plante's Ferry (84.7)	8/7-9/14	**0.1** J	0.1 U	0.1 U	**0.1** J
328441	(replicate)		**0.2** J	0.1 U	0.1 U	**0.2** J
328443	SPMD blank	-	0.1 U	0.1 U	0.1 U	0.1 U
328444	Dialysis blank	-	0.1 U	0.1 U	0.1 U	0.1 U

U = not detected at or above reported value (i.e., less than)
NJ = evidence that analyte is present; result is an estimate
J = analyte positively identified; result is an estimate

For 2,2',5,5'-PCB, laboratory sampling rates (R_s) of SPMDs containing 1 gram of triolein are 5 liters/day (@ 20 degrees C, average for Idaho border) and 3.8 liters/day (@ 14 degrees C, average for Plante's Ferry Park) (J. Huckins, personal communication). Temperature data for the period of SPMD deployment were obtained through Washington Water Power Co. (E. Johnson, personal communication). Correcting R_s for the smaller amount of triolein in the present application (0.91 vs. 1 gram) gives 4.4 and 3.4 liters/day, respectively.

Results of these calculations are shown in Table 14. River flows for the estimates of PCB loads during the sampling period were calculated from the USGS gaging stations at Post Falls Dam (mile 101.7) and Spokane (mile 72.9). In order to estimate flow at Plante's Ferry Park (mile 85.0), flows were apportioned in accordance with a hydrologic study of the Spokane River (Patmont et al., 1985). Because river flows at both sites more than doubled for the last three days the SPMDs were deployed, data for September 12 - 14 were not included.

Table 14. Estimates of Dissolved PCB-1248 Concentrations and Loads for Upper Spokane River, 1994

Location (river mile)	Dates	Est. Concentration (ug/L (ppb))	Ave. Flow (cfs)	Est. Load (gm/day)
State Line (96.5)	8/9-9/14	0.0008	224	0.4
Plante's Ferry (84.7)	8/7-9/14	0.0010 - 0.0019	426	1 - 2

cfs = cubic feet per second

The concentration of dissolved PCB-1248 was estimated to be 0.0008 ug/L (ppb) at the state line and 0.0010 - 0.0019 ppb at Plante's Ferry. Kaiser has reported similar concentrations of soluble PCB-1248 based on SPMDs deployed above and below their facility during approximately the same time period (Hart Crowser, 1995). Their results show no PCBs detected above the mill (0.0002 ppb or less), while 0.0018 and 0.0013 ppb were detected downstream.

These results should be considered approximations because of the small sample size and assumptions used in the calculations. Although the data show concentrations of dissolved PCB-1248 increased between the state line and Plante's Ferry Park, the absolute amount of increase is in question due to the uncertainty associated with the near-detection-limit concentrations of PCBs in the upstream samples. The close agreement among the several independent measurements downstream of Kaiser supports the conclusion that the average concentration of dissolved PCB-1248 was about 0.0015 ppb during the 1994 low flow season.

Conclusions About PCB Sources

PCB-1248 and -1260

Results on fish and sediment samples indicate no important sources of PCBs above Post Falls. The largest PCB inputs to the Spokane River appear to have occurred between the state line and Upriver Dam.

In the reach between the state line and Monroe St. Dam there is a region of elevated PCB-1248 in the sediments beginning at Myrtle Pt. Four facilities within this reach were identified as having elevated concentrations of PCB-1248 in their waste streams, sludge or soil: Liberty Lake STP, Spokane Industrial Park, Kaiser Trentwood, and an area adjacent to the old Inland Metals site (Figure 17).

No data are available to determine what the relative importance of each of these PCB sources has been or when discharge of PCBs may have begun. Current data on PCB discharges to the river exist only for Kaiser.

It is likely that Liberty Lake STP is a current source of PCB-1248 to the river, as shown by the unusually high concentrations in its sludge. Their discharge is small relative to Kaiser, 0.3 mgd vs. 28 mgd, but is higher in TSS concentrations by factors of 5 - 10 (Das, 1994), which increases their potential as a PCB source to the river.

Given the concentrations of PCB-1248 found in the oxidation ditch sludge, Spokane Industrial Park had been a source of -1248 to the upper river until their wastewater

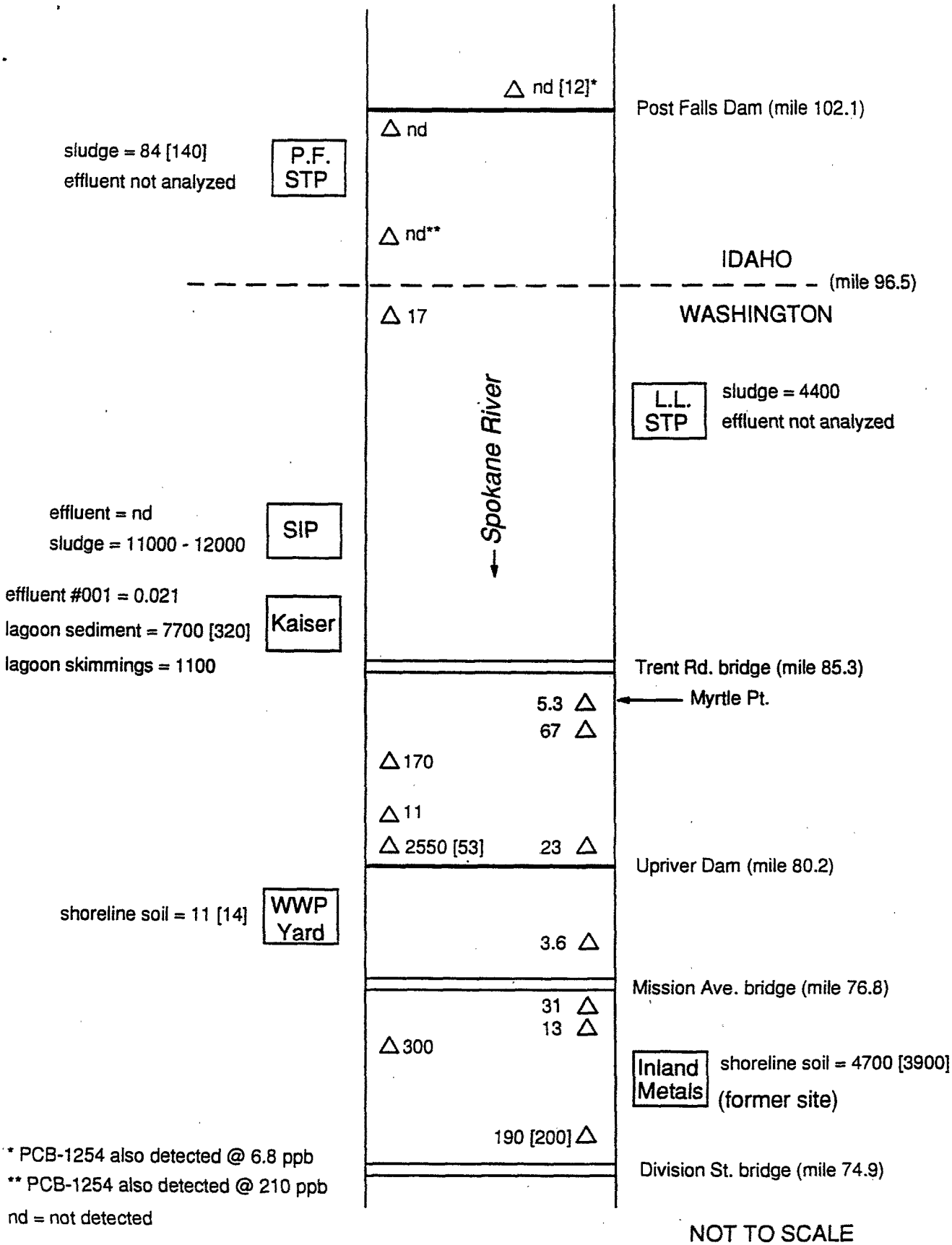

Fig. 17. Diagram Showing 1993-94 Data on PCB-1248 [PCB-1260] in Sediments (△) and Potential Sources to Upper Spokane River (ppb)

began going to Spokane STP in late 1993. The source of PCBs may still exist within SIP.

Kaiser is currently discharging PCB-1248 to the river, although concentrations appear to have been reduced substantially since cleanup of the treatment lagoon in 1992-93. PCB-1260 was also detected in effluent from the industrial wastewater treatment facility, but concentrations in lagoon sediments were relatively low and it could not be detected in the final effluent. Kaiser's contribution of PCBs to the river is further evaluated later in this report.

The old Inland Metals site has probably been a source of PCB-1248 and -1260 to the river. Although contaminated soils were removed by 1992, some residual contamination remains along the shoreline. The only instance of elevated PCB-1260 in Spokane River sediments occurred in the sample downstream of this site.

As noted earlier in this report, the preponderance of PCB-1260 in fish samples from the Little Spokane River suggests there may be a source of -1260 in this drainage.

PCB-1254

None of Ecology's samples from the industrial or municipal sites investigated were judged to have PCB distributions similar to -1254, the mixture present at the highest concentrations in most fish samples. The laboratory employed by SIP concluded the PCBs detected in their effluent and sludge resembled -1254 more closely than -1248. There are also historical reports of PCB-1254 being detected in sludge from the Spokane STP and soil at the old Inland Metals site.

The distribution of PCB-1254 in the river sediments suggests a source or sources between Post Falls Dam and the state line, and in the lower river. Failure to detect PCB-1254 in water column and, with one exception, sediment samples in the upper river, and the general downstream trend toward decreasing concentrations of -1254 in fish, suggest there are probably not significant sources in these areas.

Possible reasons for weak evidence of land-based sources of PCB -1254 to the river include: 1) sources may have been primarily historical, 2) persistence of the more highly chlorinated compounds in PCB-1248, and 3) differences between laboratories in interpretation of analytical results, as noted above for example.

Environmental processes favor the persistence and uptake of PCB compounds that co-occur in PCB-1248 and -1254 (refer to Figure 3). The lighter, less chlorinated compounds (three or fewer chlorines) in PCB-1248 are subject to volatilization and biodegradation. PCBs with four or more chlorines (which make up the bulk of -1254)

are persistent and more likely to accumulate in sediments and be taken up by biota. On a global scale, it has been observed that the composition of PCBs in the atmosphere is similar to Aroclor-1242, while in surface waters the composition is more like -1254, and in biota approximates the composition of -1260 (Callahan et al., 1979). Over time and with biological cycling, PCB-1248 weathers toward a more highly chlorinated mixture that overlaps with -1254.

Kaiser PCB Discharge

Equilibrium partitioning theory predicts that most of the PCB-1248 in the Spokane River and Kaiser final effluent would be in dissolved, rather than particulate, form because of the low suspended solids concentrations. Under equilibrium conditions, equation 3) defines the relationship between PCB concentrations in the particulate and dissolved phases.

3) $C_d = C_p / (f_{oc} * K_{oc})$

where C_d is the dissolved concentration, C_p is the particulate concentration, f_{oc} is the dry weight fraction of organic carbon, and K_{oc} is the organic carbon/water partition coefficient for PCB-1248.

Setting f_{oc} at 0.15, based on a typical range of 0.10 - 0.25 for suspended solids in rivers (EPA, 1994), and K_{oc} at 449,300 (EPA, 1980b; DiToro et al., 1991), and solving equation 4) for C_p = 220 ppb, the concentration measured in river particulates, gives a concentration of 0.0033 ppb dissolved PCB-1248. This result compares reasonably well with the long-term average concentrations of 0.0010 - 0.0019 ppb dissolved -1248 estimated from SPMDs deployed at this site.

TSS concentrations in the river were near or below detection limits of 1 mg/L at the time the particulates were collected (Table 12). A TSS concentration of 0.6 mg/L (ppm) was estimated from the weight of the particulate sample (109 gm), percent solids (10.1%), volume of water processed (22,207 L (5867 gal.)) and an 82% capture efficiency for the centrifuge (Yake, 1993).

At 0.6 mg/L TSS in the river, the concentration of PCB-1248 associated with particulates would be 0.00013 ug/L (ppb). The estimated total concentration of PCB-1248 would then be 0.0034 ppb (0.0033 ppb dissolved + 0.00013 ppb particulate). In other words, almost all (about 90%) of the -1248 would be dissolved.

At an effluent flow rate of 28.8 mgd (44.6 cfs) and river flow of 482 cfs, a PCB-1248 concentration of 0.0019 ppb (particulate + dissolved) would result in the river from complete mixing of Kaiser's discharge of 0.021 ppb, as measured by Ecology (Table

10). Kaiser used their monitoring data to calculate an increase in river PCB concentrations of approximately 0.0012 ppb (particulate + dissolved) during August and early September, 1994 (Hart Crowser, 1995). The Kaiser contribution of PCB-1248 appears to be on the same order as that found downstream, although uncertainties in determinations of PCB concentrations allow for other sources also of the same magnitude.

Concentrations of PCBs in the range of those estimated for this part of the Spokane River are well within EPA aquatic life water quality criteria of 2.0 ppb and 0.014 ppb for acute and chronic exposure to PCBs. Much lower water quality criteria have been set or proposed for PCBs, such as the EPA National Toxics Rule (40 CFR Part 131) and Great Lakes Water Quality Initiative (EPA, 1993c). It is beyond the scope of this report to recommend acceptable PCB concentrations for the river.

Proposed Further Cleanup at Kaiser

Over the past year, Kaiser Trentwood conducted studies to locate remaining sources of PCBs. They have sampled water and sediments within the wastewater collection system and other areas where contamination could occur. A direct, ongoing source of PCBs has not been found. However, Kaiser has identified a cooling water line that has accumulated sediments high in PCBs and suspect this is the source of -1248 in the final effluent. (P. Hallinan, 1995)

Kaiser is planning to inspect the cooling water line by remote TV. Following inspection, the line will be cleaned out and the pipe re-lined with new material. This work is scheduled to be completed in the fall of 1995. (P. Hallinan, 1995).

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Appendices

Appendix A - Field and Laboratory Methods

SAMPLING METHODS

Fish and Sediments

Fish were collected by electroshocking, gill net, or fyke net; crayfish were caught in baited traps. Individuals selected for analysis were measured for length and weight, then wrapped in aluminum foil, and placed in polyethylene bags. Scale samples were obtained from the 1994 fish samples but have not been analyzed. The fish samples were held on ice for transport to the Ecology Manchester Environmental Laboratory where they were frozen.

River sediments were collected with 0.02 or 0.05 m^2 stainless steel Ponar grabs or, in two cases, scraped from the shallows with stainless steel spoons (Appendix D). Composites from individual grabs were homogenized by stirring, split into priority pollutant-cleaned 8 oz. glass jars (PCBs) or other appropriate containers, and held on ice for transport to Manchester Laboratory. All sample handling equipment was stainless steel, pre-cleaned with Liqui-Nox detergent, de-ionized water, pesticide-grade acetone, and pesticide-grade hexane. Sediments were held at 4C at Manchester Laboratory until extracted.

Industrial/Municipal Facilities

Samples of sludge, treatment lagoon sediment/skimmings, and soil were composites taken with a Ponar grab or stainless steel spoons, cleaned and handled as described above for river sediments.

Effluent samples were simple grabs taken with pre-cleaned stainless steel beakers, transferred to priority pollutant cleaned one-gallon glass jars, and held on ice for transport to Manchester Laboratory. Blanks were prepared in the field by using the stainless steel beakers to fill sample containers with organic-free water prepared at Manchester Laboratory.

River Water

To collect particulates, two Sedisamp II continuous-flow centrifuges were operated for a three-day period during July 30 - August 5, 1994 at each of the two sampling sites shown in Figure 9. Centrifuge parts coming in contact with river water were stainless steel or teflon-lined. Suction was provided by peristaltic pumps with silastic tubing. The intake line was polyethylene tubing and included polycarbonate flow meters.

The centrifuges were pre-cleaned by washing with Liqui-Nox detergent, followed by sequential rinses with hot tap water, 10% nitric acid, de-ionized water, and pesticide-grade acetone. Centrifuge field blanks analyzed as part of other Ecology surveys have not had any detectable PCBs (Yake, 1993).

For the Barker Rd. sample, the intake was located 2 feet below the surface, in 5 feet of water, approximately 125 feet out into the river from the north shore. At Plante's Ferry Park, the intake was 3 feet below the surface, in 8 feet of water, approximately 80 feet out from shore. Samples of intake water were periodically analyzed for total suspended solids (TSS) and TOC.

The SPMD is a passive sampler consisting of thin-walled, polyethylene tubing filled with triolein, a synthetic lipid (Huckins et al., 1990, 1993). This sampler mimics the bioaccumulation process whereby lipid-soluble compounds like PCBs are taken up from water by diffusion through gills and other biological membranes. The apparatus used in the Spokane River consisted of 91.4 cm lengths of 2.5 cm wide tubing (80 um wall thickness) with 1 mL (0.91 gram) of triolein.

The SPMDs were wound around a stainless steel/teflon support which was suspended in a perforated stainless steel canister. SPMD preparation and packaging was done by CIA Labs, St. Joseph, MO. The canisters were attached to 50-pound concrete blocks and placed at four sites in the river (Figure 9): just west of the I-90 bridge at the Idaho border (8/9/94); at Plante's Ferry Park near Myrtle Point (8/7/94); at Harvard St. bridge (8/9/94); and at Barker Rd. bridge (8/9/94). The canisters were cleaned with Liqui-Nox detergent, de-ionized water, pesticide-grade acetone, and pesticide-grade hexane immediately prior to deployment.

The Idaho border and Plante's Ferry Park SPMDs were retrieved 9/14/94; the other SPMDs were lost to the river. SPMDs were removed from the canisters, re-packaged in solvent-cleaned metal paint cans (original shipping containers), and mailed back to CIA Labs for dialysis (extraction).

PREPARATION OF TISSUE SAMPLES

Fish collected for whole body analysis were homogenized in a Hobart commercial meat grinder. Edible tissue samples were fillets excised with stainless steel knives and included the skin. Fish were scaled and rinsed with tap water and de-ionized water prior to filleting. Fillets were homogenized with a meat grinding attachment for a Kitchen-Aid food mixer.

Instruments and equipment used to prepare the tissue samples were washed with Liqui-Nox detergent and rinsed with de-ionized water, pesticide-grade acetone, and pesticide-grade hexane. Equipment use to process fish for lead analysis was rinsed with dilute, reagent-grade nitric acid. Sample containers were 4 or 8 oz. priority pollutant-cleaned glass jars. The samples were re-frozen pending analysis.

ANALYTICAL METHODS

Methods of sample analysis and laboratories employed in the Spokane River PCB surveys are described in Table 2.

PCBs were analyzed by EPA Method 8080. The fish and solids samples were extracted with acetone. Effluents were extracted with methylene chloride.

Extracts were cleaned-up using gel permeation chromatography (GPC) and Florisil clean-up. Acid treatment of the extracts was used to remove interferences due to polar compounds. Sulfur was removed with elemental mercury.

CIA Labs dialyzed the SPMDs in hexane and cleaned-up the extracts by GPC. The extracts were further cleaned-up at Manchester Laboratory using Florisil techniques.

PCB analysis was by dual, dissimilar column, capillary gas chromatography (GC) with electron capture detection (ECD). PCBs were quantitated by comparing residue peaks to peaks from Aroclor standards. Retention times for DDT analogs were determined to identify peaks caused by co-elution of these compounds with PCBs.

QUALITY ASSURANCE

The quality of the PCB data was assessed by evaluating: 1) sample holding times, 2) laboratory blanks, 3) surrogate spike recoveries, 4) matrix spike & spike duplicate recoveries, 5) standard reference materials, and 6) split samples. Overall, the results show the PCB analyses to be accurate.

Sample Holding Times and Laboratory Blanks

Except for the August 1994 sediments, all PCB samples were analyzed within the recommended holding time of 14 days after extraction. Low recovery of surrogate spikes for some of the August 1994 sediments required their re-extraction. Analysis of the new extracts took place 13 - 16 days past holding time. Due to the stability of PCBs, this should have no effect on results reported for these samples (Huntamer, 1994a)

Laboratory blanks were analyzed with each batch of samples. No target compounds were detected in any of the blanks.

Spike Recoveries

Table 3 summarizes Manchester Laboratory's results on spikes of PCB surrogate compounds and matrix spikes / matrix spike duplicates. These data provide estimates of the accuracy and precision of the analysis.

PCB surrogates were spiked into each sample prior to extraction. With the exceptions noted below, recovery of surrogate compounds was within acceptable limits established by the EPA Contract Laboratory Program (CLP).

Recoveries of the surrogate dibutylchlorendate (DBC) were variable and often low. DBC is prone to interferences from high concentrations of PCBs and has low recoveries after Florisil clean-up. The DBC recoveries did not require qualification of the data and are not included in Table 3. Some of the 1994 fish and sediment samples had surrogate recoveries within CLP

requirements, but as low as 44% and 37%, respectively. Recoveries of decachlorobiphenyl (DCP), the surrogate which most closely resembles PCBs present in commercial mixtures, were always greater than 50% in the 1994 fish and sediments.

In samples 94-218080 (5/94 soil near old Inland Metals site) and 94-218088 (5/94 sludge from Spokane Industrial Park) recoveries of DCP could not be determined due to interferences. Since recoveries of other surrogates in these samples were good (74 - 94%) no qualifiers were added to the data.

Matrix spikes of PCB-1242 and -1260 were analyzed in duplicate for every batch of 10 or fewer samples. Recoveries were acceptable in all samples except number 94-328435 (Idaho largescale sucker) where interferences prevented recovery of the PCB-1260 spike. Recoveries of PCB-1242 in this sample were 111 - 115%. The matrix spikes analyzed in conjunction with sludges and other solids collected in May 1994 were overwhelmed by the amount of native PCBs in the sample selected for spiking (94-218080).

Results among duplicate matrix spikes agreed within 10% or better for the majority of samples. Matrix spikes were not done on SPMD samples.

Standard Reference Materials and Split Samples

Standard reference materials, marine harbor sediments HS-1 and HS-2, prepared by the National Research Council Canada and containing certified concentrations of PCB-1254, were analyzed in duplicate along with the 1993 sediment samples. Results showed good accuracy at both lower and higher levels of PCBs (Table 4).

Field samples were analyzed in duplicate to assess the overall precision of the PCB data on fish and sediments. Table 5 shows the concentrations of total PCBs measured in the splits. These results suggest that concentration differences among samples on the order of 5% or less for fish and 25% or less for sediments could be attributable to laboratory rather than field variability.

Corrections to 1993 Data

Following publication of the report of the 1993 survey, questions about the identification of PCB mixtures in the samples caused Manchester Laboratory to review their analyses. The samples had initially been interpreted as having three components, PCB-1242, PCB-1254, and PCB-1260. This interpretation was carried through all samples and results calculated on that basis.

Re-examination of the data established that PCB-1248 had been misidentified as PCB-1242. The corrected data for PCB-1248 and -1254 were qualified as estimates ("J" qualifier) due to overlap of these two mixtures. No changes were made to results for PCB-1260. Concentrations of total PCBs in the samples remained essentially unchanged (Huntamer, 1994b).

Table A-1. Analytical Methods and Laboratories for 1993-94 Spokane River PCB Surveys

Sample Type	Analysis	Method	Description	Laboratory
Fish Tissue	PCBs	EPA Method 8080	Acetone extraction. Dual column GC/ECD	Ecology Manchester Environmental Laboratory
" "	% Lipid	EPA Region 10 Method RX1-608.5	Dry and weigh aliquot of extract	Ecology Manchester Environmental Laboratory
Sediment and other solids	PCBs	EPA Method 8080	Acetone extraction, Dual column GC/ECD	Ecology Manchester Environmental Laboratory
" "	TOC*	Puget Sound Estuary Program Method	Combustion w/ CO2 measurement	Sound Analytical Services, Tacoma, WA
" "	% Solids	Puget Sound Estuary Program Method	Dry @ 104 C	Ecology Manchester Environmental Laboratory
Sediment	Grain Size	ASTM D-422	Seive and pipet	Soil Technology Inc., Bainbridge Is., WA
"	Bioassay	Hyalella azteca (amphipod)	10-day survival	Ministry of Environment Laboratory, Etobicoke, Ont.
"	"	Microtox (bacteria)	Reduction in light output, deionized water extract	Parametrix Inc., Seattle, WA.
Effluents	PCBs	EPA Method 8080	MeCL2 extraction, Dual column GC/ECD	Ecology Manchester Environmental Laboratory
SPMDs	PCBs	in-house EPA Method 8080	Dialysis w/ hexane, Dual column GC/ECD	CIA Labs, Columbus, MO Ecology Manchester Environmental Laboratory

* total organic carbon

Table A-2. Summary of Surrogate and Matrix Spike Recoveries for Spokane River PCB Analyses, 1993-94

Sample Set	Sample Numbers	Surrogate Spike Recoveries*	Matrix Spike & Spike Duplicate Recoveries**	Matrix Spike RPDs
7-8/93 Fish	93-318240 to -318258	83 - 101 %	74 - 84 %	0 - 6.5 %
8/94 Fish	94-318230 to -318266, -328414, & -328425 to -328438	44 - 118 %	91 - 144 %	2.3 - 25.9 %
7/93 Sediments	93-31820 to -318236	75 - 94 %	95 - 104 %	6.2 - 9.0 %
8/94 Sediments	94-318270 to 318275, 94-328400 to -328413	37 - 100 %	90 - 100 %	1.1 - 10.5 %
8/94 Sediments (bioassay)	94-328001 to -328003	66 - 89 %	93 - 100 %	1.1 - 10.5 %
5/94 Sludge and other solids	94-218080 to -218093	62 - 104 %	native PCBs >> spike	-
8/94 Sludges	94-318166, 69, & 74	73 - 123 %	99 - 108 %	2.8 - 5.8 %
8/94 Effluents	94-318153 to -318179	72 - 117 %***	92 - 101 %	0 - 7.7 %
8/94 Particulates	94-318158 & -318172	42 - 91 %	99 - 108 %	2.8 - 5.8 %
8-9/94 SPMDs	94-328440 to -328444	66 - 105 %	na	-

* decachlorobiphenyl and 4,4-dibromooctafluorobiphenyl (+ tetrachlorometaxylene in 1994 samples)
** PCB-1242 and -1260
***decachlorobiphenyl
RPD = relative percent difference (duplicate range as percent of mean)
na = not analyzed
>> = much greater than

Table A-3. PCB-1254 Concentrations Measured in Standard Reference Material (ug/Kg (ppb))

SRM	Matrix	Sample Number	Analysis #1	Analysis #2	Certified Value
HS-1	Sediment	93-318237	25 J	27 J	21.8+/-1.1
		93-318238	16.5	15.3	
HS-2	Sediment	93-318239	99	98	111.8+/-2.5
		93-318240	65	na	

J = estimated value

na = not analyzed

Table A-4. Precision of PCB Analysis on Split (Duplicate) Samples
(ug/Kg (ppb))

Sample Number	Total PCBs Analysis #1	Analysis #2	RPD
	Fish Tissue		
93-318251	9.2 J	9.6 J	4.2 %
94-328436	97 J	98 J	1.0 %
94-318260	393 J	377 J	4.2 %
94-318261	740 J	471 J	44 %
93-318243	2780 J	2770 J	0.4 %
	Sediment		
94-328408	nd	nd	nd
94-328403	17	nd	nd
94-318274	20 J	26 J	26 %
93-318231	53 J	44 J	19 %
94-318237	2453 J	2700 J	9.6 %

RPD = relative percent difference (duplicate range as percent of mean)
J = estimated value
nd = not detected

Appendix B. Lengths and Weights of Spokane River Fish and Crayfish Analyzed for PCBs in 1994

Sample Number (94-)	Species	Total Length (mm)	Fresh Weight (gm)
	Spokane Arm, August 2, 1994		
318230	Walleye	370	467
		269	175
		243	112
		245	98
		260	163
		225	73
		257	135
		236	95
318231	Walleye	362	364
		255	147
		242	94
		213	79
		250	145
		243	135
		238	106
		255	114
318232	Walleye	374	430
		309	214
		255	116
		243	107
		231	119
		255	126
		487	365
		239	98
	Long Lake, August 2, 1994		
318233	Northern Squawfish	370	500
		368	415
		465	935
		357	400
		407	580
		350	362
		341	330
		399	515
318234	Northern Squawfish	383	455
		375	445
		375	440
		383	435
		352	370
		445	720
		388	485
		368	450
	Long Lake, August 2, 1994		
318235	Northern Squawfish	378	415
		354	365
		418	585
		369	455
		417	595
		396	538
		355	330
		415	590
318240	Largemouth Bass	335	695
		340	665
		368	825
		313	485
		450	1535
318247	Largemouth Bass	320	567
		405	1097
		395	1096
		400	1119
		340	649
318241	Brown Trout	390	580
		262	181
		275	219
318243	White Crappie	294	513
(328436	duplicate)	269	385
		210	163
		210	196
		202	164
		198	135
		275	421
318244	Yellow Perch	217	144
		250	210
		215	144
		256	209
		206	131
		245	202
		225	173
		282	311

Appendix B . (continued)

Sample Number (94-)	Species	Total Length (mm)	Fresh Weight (gm)
	Long Lake, August 2, 1994		
318245	Yellow Perch	248	210
		255	259
		217	153
		246	190
		245	221
		280	298
		250	246
		217	166
318246	Yellow Perch	225	153
		210	131
		215	147
		225	164
		245	237
		248	220
		217	166
		198	118
318249	Mountain Whitefish	325	374
		296	222
		232	107
		244	125
		227	89
		225	98
		233	102
		234	100
318250	Mountain Whitefish	334	337
		250	134
		205	69
		236	101
		238	112
		225	91
		240	121
318251	Mountain Whitefish	228	104
		245	116
		206	79
		235	110
		225	91
		232	83
		245	125
	Long Lake, August 2, 1994		
318253	Crayfish	-	66
		-	48
		-	74
318248	Largescale Sucker	484	1171
		513	1443
		475	1190
		482	908
		417	740
		450	883
		454	704
		470	1004
	Little Spokane River, August 3, 1994		
318237	Mountain Whitefish	324	280
		310	270
		326	300
		305	280
		290	205
		342	345
		313	285
		334	350
318238	Mountain Whitefish	283	220
		277	215
		294	215
		230	93
		327	292
		280	200
		241	112
		239	116
318239	Mountain Whitefish	325	295
		277	208
		217	90
		224	98
		287	215
		294	231
		305	264
		305	256
318242	Cutthroat Trout	345	420

Appendix B . (continued)

Sample Number (94-)	Species	Total Length (mm)	Fresh Weight (gm)
	Little Spokane River, August 3, 1994		
318236	Largescale Sucker	430	825
		450	855
		485	1145
		460	1070
		438	780
	Nine-Mile Reservoir, August 5, 1994		
318254	Rainbow Trout	370	608
		390	657
		420	852
		397	740
		393	639
		470	1230
318255	Rainbow Trout	355	580
		425	877
		380	661
		400	625
		376	563
		440	947
318256	Rainbow Trout	395	613
		351	468
		435	1007
		442	1129
		427	770
		474	1301
318257	Mountain Whitefish	245	149
		238	124
		235	118
		236	119
		235	118
		238	120
		220	95
		225	96
318258	Mountain Whitefish	234	117
		224	102
		230	110
		255	164
		232	109
		298	274
		235	121
		237	142
	Nine-Mile Reservoir, August 5, 1994		
318259	Mountain Whitefish	348	416
		235	128
		236	124
		305	300
		228	105
		246	148
		236	116
		236	118
	Monroe St. to Upriver Dam, August 8, 1994		
328425	Rainbow Trout	280	207
		309	293
		224	120
		352	419
		296	262
		321	322
		195	67
		370	472
328426	Rainbow Trout	197	79
		300	265
		339	355
		192	62
		296	287
		247	160
		268	163
328427	Rainbow Trout	220	109
		280	233
		286	463
		217	104
		240	131
		229	136
		221	94
328428	Mountain Whitefish	326	340
		305	259
		218	105
		295	222
		319	323
		302	263
		242	144

Appendix B. (continued)

Sample Number (94-)	Species	Total Length (mm)	Fresh Weight (gm)
	Monroe St. to Upriver Dam, August 8, 1994		
328249	Mountain Whitefish	322	293
		311	275
		230	125
		285	206
		307	269
		318	246
		307	324
		319	316
328430	Mountain Whitefish	317	278
		298	270
		335	312
		340	334
		235	126
		307	287
		230	115
		246	136
328432	Crayfish	-	43
		-	63
		-	54
		-	82
		-	56
		-	55
		-	45
		-	83
328433	Crayfish	-	60
		-	47
		-	69
		-	54
		-	56
		-	75
		-	40
		-	43
328434	Crayfish	-	70
		-	75
		-	56
		-	45
		-	51
		-	58
		-	60
		-	67
	Monroe St. to Upriver Dam, August 8, 1994		
328431	Largescale Sucker	386	516
		453	793
		406	677
		430	744
		403	603
	Upriver Dam to Trent Rd., August 6, 1994		
318260	Rainbow Trout	454	915
	(duplicate analysis)	319	358
		331	395
		275	197
		428	701
		389	262
		284	279
		353	445
318261	Rainbow Trout	310	317
	(328437 duplicate)	325	411
		225	130
		313	308
		323	329
		335	388
		318	298
		400	679
318262	Rainbow Trout	285	284
		350	444
		300	296
		341	453
		276	195
		350	449
		319	325
		218	118
318263	Largescale Sucker	377	525
		399	653
		410	680
		485	1188
		415	680

x B . (continued)

Species	Total Length (mm)	Fresh Weight (gm)
Upriver Dam to Myrtle Pt., August 6, 1994		
Crayfish	-	108
	-	39
	-	46
	-	91
	-	74
	-	96
	-	48
	-	35
Crayfish	-	44
	-	39
	-	102
	-	82
	-	60
	-	82
	-	69
	-	40
Crayfish	-	72
	-	40
	-	43
	-	62
	-	45
	-	54
	-	57
	-	69
Corbin Park, Idaho, August 10, 1994		
Largescale Sucker	540	1875
	474	1185
	505	1265
	442	1029
	516	1362

Scientific Names:

Brown Trout	Salmo trutta
Cutthroat Trout	Oncorhynchus clarki
Largemouth Bass	Micropterus salmoides
Largescale Sucker	Catostomus macrocheilus
Mountain Whitefish	Prosopium williamsoni
Northern Squawfish	Ptychocheilus oregonensis
Rainbow Trout	Oncorhynchus mykiss
Walleye	Stizostedion vitreum
White Crappie	Pomoxis annularis
Yellow Bullhead	Ictalurus natalis
Yellow Perch	Perca flavescens

Appendix C. Lengths and Weights of Spokane River Fish and Crayfish Analyzed for PCBs in 1993

Sample Number (93-)	Species	Total Length (mm)	Fresh Weight (gm)
	Spokane Arm, July 25-27, 1993		
318245	Walleye	315	225
		328	275
		322	275
		308	229
		315	272
318247	Smallmouth Bass	230	186
		220	191
		226	196
		220	195
		255	285
318246	Kokanee	210	106
		270	239
318240	Largescale Sucker	490	1265
		510	1313
		497	1291
		368	978
		504	1514
	Long Lake, July 26-28, 1993		
318248	Crayfish	58*	41
		58	56
		60	53
		60	58
		62	71
318251	Yellow Perch	235	168
		198	99
		232	158
		236	199
		242	186
	Long Lake, July 26-28, 1993		
318250	Mountain Whitefish	315	227
		332	311
		324	281
		296	222
		278	169
318249	Largemouth Bass	463	1702
		457	1756
		347	677
		370	853
		332	478
318241	Largescale Sucker	450	867
		487	1133
		432	760
		490	1099
		485	975

* carapce length

ppendix C . (continued)

ample umber)3-)	Species	Total Length (mm)	Fresh Weight (gm)	Sample Number (93-)	Species	Total Length (mm)	Fresh Weight (gm)
	Nine-Mile Reservoir, August 10, 1993				Upriver Dam to Myrtle Pt., July 27, 1993		
18253	Rainbow Trout	284	221	318256	Rainbow Trout	280	241
		293	171			285	255
		232	135			240	161
		238	129			331	393
						305	286
18252	Rainbow Trout	384	608	318255	Rainbow Trout	373	498
		295	237			360	528
		334	364			333	374
		356	432			386	541
						365	464
18254	Mountain Whitefish	249	131				
		249	155	318243	Largescale Sucker	505	1367
		245	122			406	637
		235	104			427	721
		232	111			410	739
						420	723
18242	Largescale Sucker	553	1834		Post Falls, Idaho, August, 9, 1993		
		539	1691	318244	Largescale	411	802
		542	1530		Sucker		
		504	1354				
		447	889				

Appendix D . Locations of Ecology 1993-94 Sediment Sampling Sites in the Spokane River*

Site Name	Sample Number	Latitude (47 N)	Longitude (117 W)	River Mile	Date	Remarks
Above Post Falls Dam	318236	42' 00"	56' 42" (116 W)	102.6	7/27/93	Left** bank embayment upstream of bridge to S. City Park
Above Post Falls STP	328406	42' 38''	58' 08''* (116 W)	101.7	8/10/94	Just upstream from sewage treatment plant outfall; scraped fine material from around rocks near water's edge at right bank.
Pleasant View Road	328408	41' 46''	00' 10''	99.0	8/10/94	End of Pleasant View Rd. near old bridge on right bank; spooned from pocket of fine grained material among rocks just below waterline. Site of May 26, 1994 sample.
State Line	328403	41' 28''	04' 07''	94.8	8/9/94	1 mile downstream of state line; in back eddy behind gravel bar, right bank, fine material. Split sample with CH2M Hill.
Myrtle Point	318270	41' 51''	14' 36''	84.5	8/7/94	Left bank at Myrtle Point; difficult to get fine material, grab blows surface floc away.
1/2 Mile below Myrtle Point	318271	41' 36''	14' 08''	84.0	8/7/94	On left bank just below Myrtle Pt. and just above foot/bike bridge; fine material in backwater.
Beach below Myrtle Point	318272	41' 21''	15' 52''	83.4	8/7/94	Swimming beach about 1/2 mile below Myrtle Pt. on right bank. Split sample with CH2M Hill.
Boulder Beach	318275	41' 42''	18' 09''	81.5	8/7/94	Upstream side of Boulder Beach, right bank; fairly coarse material.
Upriver Dam Station #1	318235	41' 53''	19' 10''	80.6	7/27/93	Off right bank about 1/4 mile above dam.
Upriver Dam Station #1	318273	41' 53''	19' 10''	80.6	8/7/94	Right bank about 1/4 mile above dam; last year's hot spot (Ecology July 27, 1993 sample), material looks the same. Split sample with CH2M Hill.
Upriver Dam Station #1	328001	41' 53''	19' 10''	80.6	8/7/94	Sample for bioassay, top 5 cm.
Upriver Dam Station #2	318274	41' 07''	19' 23''	80.6	8/7/94	Left bank opposite site #1 (above); fine but different appearance than #1.

Appendix D. (continued)

Site Name	Sample Number	Latitude (47 N)	Longitude (117 W)	River Mile	Date	Remarks
Below WWP Substation	328400	40' 35''	21' 07''	78.7	8/8/94	Left bank, opposite and just downstream of WWP substation; coarse sand with some organic material.
Mission Avenue Bridge	328401	40' 18''	23' 07''	76.6	8/8/94	Left bank under Mission Ave. bridge; fine sand under layer of floc.
Old Bridge	328402	39' 32''	23' 35''	75.7	8/8/94	Just upstream of boat ramp at old bridge abutment below Trent Ave.; only obtained one good grab.
Near Postal Terminal	328404	39' 39''	23' 55''	75.4	8/9/94	Right bank near Postal Terminal, opposite and slightly upstream from former site of Inland Metals facility; medium coarse sand with quite alot of fine material. Split sample with CH2M Hill.
Above Division Street	328405	39' 51''	24' 24''	74.9	8/9/94	Left bank 1/4 mile upstream of Division St.; fine sand with some silt.
Above Nine-Mile Dam	318234	45' 54"	33' 00"	58.7	7/28/93	From outer margin of exposed left bank shoal, 1/4 mile below Deep Creek. (River drawn down at time of collection)
Long Lake	318231	49' 48"	44' 54"	39.0	7/26/93	Upstream of DNR campgound, center channel.
Long Lake	328002	49' 48"	44' 54"	39.0	8/9/94	Sample for bioassay, top 5 cm.
Spokane Arm	318230	53' 00"	09' 00" (118 W)	13.2	7/27/93	Porcupine Bay, upstream of Blue Creek, center channel.
Spokane Arm	328003	53' 00"	09' 00" (118 W)	13.2	8/10/94	Sample for bioassay, top 5 cm.

* top 2 cm layer except as noted
** viewed looking downstream

Appendix E. PCBs in STP Sludges; Statewide Data from Ecology Class II Inspections

(ug/Kg (ppb) dry wt.)

Plant	Date	PCB -1248	PCB -1254	PCB -1260
		Greater than 10 MGD		
METRO Renton	1/94	350 U	350 U	350 U
Yakima	10/92	nd	nd	nd
Tacoma Central	6/89	380 U	770 U	770 U
Spokane	9/88	660 U	660 U	660 U
		1 to 10 MGD		
Alderwood	10/92	2700 U	2700 U	2700 U
Raymond	9/92	120 U	120 U	360 U
Chelan	7/92	3570 U	7100 U	3570 U
Olympic Terrace	3/92	5600 U	5600 U	5600 U
Mt. Vernon	12/91	65 U	65 U	65 U
Grandview	10/91	1200 U	1200 U	1200 U
Prosser	10/91	170 U	170 U	170 U
Marysville	7/90	nd	**1900***	nd
Port Orchard	1/89	800 U	1600 U	1600 U
Central Kitsap	11/88	24 U	24 U	24 U
		Less than 1 MGD		
Naches	7/93	34 U	34 U	34 U
Stanwood	9/92	125 U	250 U	250 U
Snohomish	9/92	180 U	180 U	180 U
Sequim	8/90	nd	nd	nd
Brewster	3/90	nd	nd	nd
Bingen	2/90	nd	nd	nd
Duvall	8/89	760 U	760 U	1500 U
North Bend	8/89	130 U	130 U	260 U
Snoqualmie	8/89	2000 U	2000 U	4000 U
Whidbey Naval	12/88	60 U	**720**	60 U

MGD = million gallons per day

U = not detected at or above reported value (i.e., less than)

nd = sludge data were reported in ug/L; no PCBs detected

*ug/L concentration adjusted to ug/Kg from % solids

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